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Evaluating Germ Plasm for Beef Production, Cycle I

Progress Report No. 3

U.S. Meat Animal Research Center

**In cooperation with
Kansas State University
and The University of Nebraska**

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Because of the large number of combinations of production resources and variations in beef market requirements, one type of cattle will not be most efficient in all production systems. The wide spectrum of cattle types available in the world offers the opportunity of quickly matching genetic resources with production and market requirements. Characterization of available genetic resources for economically important traits is necessary if we are to use this opportunity wisely. Initially, change in production characteristics can be made more rapidly by using existing variation among breeds than by selecting within breeds. However, selection within breeds remains the primary method for continuing change in average genetic merit.

In 1969 a germ plasm evaluation program was started at the U.S. Meat Animal Research Center. The primary objective was to characterize biological and environmental relationships among production traits relating to growth, feed use efficiency, carcass composition and quality, reproduction, maternal traits, and carcass and meat traits. Breeds or breed crosses form an identifiable source of biological or genetic variation in production traits.

The first cycle of breed crosses (Cycle I) resulted from artificial insemination (AI) of Hereford and Angus cows by Hereford, Angus, Jersey, South Devon, Limousin, Charolais, and Simmental bulls. The Hereford and Angus cows were purchased as calves from commercial producers. A large number of sires were used in the program: 32 Hereford, 35 Angus, 33 Jersey, 27 South Devon, 20 Limousin, 26 Charolais, and 27 Simmental bulls. Hereford and Angus sires were sampled from those selected on individual performance by AI organizations for their progeny testing programs. Jersey bulls were selected at random from two commercial AI organizations, and the South Devon bulls were sampled from an importation made in 1969 by a commercial organization. Charolais, Limousin, and Simmental bulls were sampled from those available from commercial organizations. In addition, Limousin and Simmental semen was obtained from the Canada Department of Agriculture. No progeny test results were available on any of the bulls at the time they were sampled for this program.

Results of analysis of data collected in various phases of Cycle I and conclusions are presented in the following six sections: I. Birth and Growth to Weaning; II. Postweaning Growth and Feed Efficiency; III. Carcass Composition, Quality and Palatability; IV. Growth and Puberty of Heifers; V. Estimating Retail Product; VI. Predictive Value of Quality Grade Factors for Palatability Characteristics.

BIRTH AND GROWTH TO WEANING[2]

Gerald M. Smith[3]

This section reports results on the characterization of the life cycle performance of Hereford, Angus, Jersey, South Devon, Limousin, Charolais, and Simmental crosses. Examined were breed differences in gestation length, birth weight, calving difficulty (dystocia), calf mortality, preweaning growth, and the interrelationships among these traits. Data are re-

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[2]Results presented here were taken from Gerald M. Smith, D. B. Laster and Keith E. Gregory. Characterization of biological types of cattle. I. Dystocia and preweaning growth. J. Anim. Sci. 43 (1976). Persons desiring a more detailed statistical evaluation are referred to this paper.

[3]Research geneticist, U.S. Meat Animal Research Center, Agricultural Research Service, Clay Center, Nebr. 68933

ported on 2,368 calves born at the U.S. Meat Animal Research Center in 1970, 1971, and 1972 as part of the Germ Plasm Evaluation Program.

Experimental Procedure

Cows were maintained on improved pastures and fed hay and silage during the winter. All cows were managed to produce their first calf as 2 year olds—they were 2 to 5 years old in 1970, 2 to 6 years old in 1971, and 3 to 7 years old in 1972. Numbers of births from cows that were 2, 3, 4, and 5 or more years old were 746, 567, 359, and 696, respectively. Calves were born from late February through early May, all calves were weighed, and males were castrated within 24 hr of birth. Early mortality included deaths at or within 24 hr of birth; late mortality included calves that died from 24 hr after birth until weaning. Calves were creep fed whole oats from mid-July until weaning in late October at about 7 mo of age. Creep-feed consumption averaged 286, 308 and 304 lb/calf in 1970, 1971, and 1972.

Cows were observed closely for calving difficulty throughout the calving season. Cows that calved without assistance and those given minor hand assistance, but delivered their calves without the aid of a mechanical calf-puller, were classified as no difficulty. Those requiring assistance with a mechanical puller or surgical removal of the calf were classified as difficult births.

Results

Data are presented by sire breed group. *Comparisons of other sire breeds with Hereford and Angus should be based on the Hereford-Angus crossbreds and not the straightbreds.* Data for straightbred Hereford and Angus are presented primarily for evaluation of heterosis in Hereford-Angus crosses. Data for Hereford and Angus dams averaged over all sire breeds are also presented.

Gestation length.—Breed group means for gestation length are presented in table 1. The 288.1 day gestation length for Limousin was longer than that for the other crosses. Simmental, Charolais, and South Devon crosses were similar in gestation length; gestation length for Hereford by Angus and reciprocal crosses and Jersey crosses was shorter than for other crosses. Calves from Angus dams averaged 3.1 day shorter gestations than those from Hereford dams. Straightbred Angus averaged 3.9 days shorter gestation than straightbred Herefords.

Calf sex and dam age also signficantly influenced gestation length. The 1.7 day longer gestation length for males (285.7 vs. 284.0) was similar to previous studies. Gestation length for 2-, 3-, 4-, and ≥5-age-of-dam subclasses was 283.5, 285.0, 285.4 and 285.5 days, respectively.

Birth weight.—Charolais and Simmental crosses were heaviest at birth and Jersey crosses were lightest (table 1). Limousin and South Devon crosses were similar in birth weights and intermediate between Charolais and Simmental crosses and the Hereford-Angus crosses. Straightbred Hereford calves were 8.4 lb heavier than straightbred Angus; a comparable 4.4 lb heavier birth weight was found for all calves from Hereford dams than for calves from Angus dams. Males were 5.9 lb heavier at birth than females (80.0 vs. 74.1).

Calving difficulty.—Jersey and Hereford-Angus crosses experienced less difficulty than other crosses, and Limousin crosses had less difficulty than Charolais crosses (table 1). Level of calving difficulty associated with different sire breeds depended upon age of the cow. Jersey crosses from 2-year-old dams had only 15 percent difficulty compared to 66 to 74 percent for the four largest breed crosses (Charolais, Simmental, Limousin and South Devon); however, these differences were much less pronounced in mature cows (table 2). Plateauing of calving difficulty in 4-year-old cows for all sire breeds except Charolais crosses and Simmental crosses indicates that only

Table 1.—*Breed group means for birth traits and late mortality*

Breed group[1]	No.[2]	Gestation length	Birth weight	Calving difficulty	Mortality[3] Early	Late
		Days	*Lb*	*Percent*	*Percent*	*Percent*
HH	141	285.5	76.5	18	3.7	4.9
AA	166	281.6	68.1	12	4.8	3.8
Heterosis (H by A)		−.6	1.9	−4	−3.0	−2.9
HA+AH	375	282.9	74.3	11	1.3	1.5
JH+JA	302	281.8	64.6	5	2.6	4.3
SDH+SDA	232	285.6	78.9	27	6.1	3.4
LH+LA	371	288.1	79.8	24	5.1	4.3
CH+CA	382	285.9	85.1	34	9.6	5.9
SH+SA	399	286.3	83.8	29	6.8	4.3
H dams	1106	286.4	79.2	24	5.4	5.0
A dams	1262	283.3	74.7	17	4.8	3.0

[1]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[2]Number of births.

[3]Early mortality is within 24 hr of birth; late mortality is from 24 hr after birth until weaning.

Table 2.—*Breed group means for birth weight, calving difficulty and weaning percentage by age of dam subclasses*[1]

Breed group[2]	Birth weight (pounds) 2	3	4	≥5	Calving difficulty (percent) 2	3	4	≥5	Calves weaned (percent)[3] 2	3	4	≥5
HH	73.4	72.5	78.7	81.1	51	12	5	3	85.2	88.3	94.9	96.4
AA	66.2	67.5	67.9	71.4	37	6	1	4	85.1	95.3	93.1	94.1
HA+AH	71.7	71.9	75.2	78.3	41	5	0	0	89.9	96.9	99.1	100.0
JH+JA	62.2	63.7	64.6	68.4	15	5	0	0	90.2	91.8	91.8	97.3
SDH+SDA	75.4	77.8	78.7	83.6	68	24	9	9	79.8	90.8	98.7	91.6
LH+LA	74.3	77.4	82.9	84.5	72	10	4	9	79.7	93.7	91.5	96.5
CH+CA	79.2	83.6	88.2	89.3	74	31	22	9	74.0	87.8	90.7	86.9
SH+SA	77.6	83.1	85.8	88.2	66	24	15	9	85.1	86.7	90.1	92.8
H dams	74.3	77.4	80.9	83.8	59	20	12	6	81.3	88.2	93.0	93.9
A dams	71.4	73.4	75.9	78.5	50	11	3	5	85.1	94.5	94.4	94.8

[1]Age of dam equals 2, 3, 4 or ≥5 years.

[2]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[3]Percentage calves weaned of those born.

in these larger crosses is increased cow size after 4 years of any advantage. The sharp decline in calving difficulty for Limousin crosses in 3-year-old cows is worth noting but not readily explainable. This rather low value (10 percent) for Limousin crosses is probably due to chance, but it does suggest that the 72 percent level in 2-year-old cows could, also by chance, be somewhat overestimated.

Pattern change in calving difficulty relative to birth weight was similar among breed groups. Difficulty increased .74 percent on the average per 1 pound increase in birth weight. Examination of birth weights and percentage of calving difficulty by age-of-dam classes suggests that the increase in calving difficulty as birth weight increases depends on age of dam. These increases were 1.5, 0.7, 0.4, and 0.2 percent per pound increase in birth weight for 2-, 3-, 4-, and ≥5-year-old cows. Calves experiencing difficult births averaged 4.9 lb heavier than calves born without difficulty (table 3). This difference was fairly consistent among sire breeds and seemingly not explained by the small (0.6 day) difference in gestation length.

Calves from Angus dams had fewer difficult births than those from Hereford dams. Heterosis of the calf had no significant effect on level of calving difficulty. After differences in birth weight were accounted for, neither years nor dam breed significantly influenced the difficulty level. Such was not the case for sires. After removing average differences in birth weight within breeds, variability in difficulty level between sires was still highly significant. The nature of this remaining variation is not known, but differences in calf shape may account for a part of it.

Calving difficulty was 12 percent less for female than for male calves (26.4 vs. 14.8). The increased difficulty associated with males tended to be greatest in young cows and in sire breeds with higher mean difficulty levels, that is, Simmental and Charolais crosses were affected most by calf sex. The difference between males and females was 23 percent in 2-year-old cows and 7 percent in mature cows.

Calf mortality.—Death losses at or within 24 hr of birth averaged 5.1 percent (table 1). Losses were highest (9.6 percent) for Charolais crosses but not

Table 3.—*Breed group means for gestation length, birth weight and early mortality by calving difficulty subclasses*[1]

Breed group[2]	Gestation length 0	1	Birth weight 0	1	Mortality[3] 0	1
	Days	*Days*	*Lb*	*Lb*	*Percent*	*Percent*
HH	285.4	285.8	76.5	77.8	4.4	2.7
AA	282.1	280.8	67.7	76.5	3.0	13.7
HA+AH	283.1	282.7	74.1	77.6	.6	5.1
JH+JA	282.1	281.8	64.8	71.9	1.8	9.1
SDH+SDA	285.0	286.4	77.2	82.7	4.7	12.0
LH+LA	287.4	289.7	77.8	84.2	1.5	17.3
CH+CA	285.4	286.6	83.1	88.9	3.4	20.0
SH+SA	286.1	286.4	83.1	84.9	5.7	8.7
H dams	286.2	286.7	78.3	82.0	3.1	11.1
A dams	283.1	283.8	73.9	79.8	3.0	11.8

[1]No calving difficulty = 0; calving difficulty = 1.

[2]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[3]Early mortality is within 24 hr of birth.

significantly different from those for Simmental and South Devon crosses. Hereford-Angus crosses had significantly fewer early deaths than all other crosses except Jerseys. The .6 percent difference between Hereford and Angus dams was not significant.

Calving difficulty significantly influenced early survival (table 3); death losses of calves with difficult births were 11.5 percent; losses for calves requiring little or no assistance were 3.1 percent. Age of dam did not significantly affect early calf survival when difficulty differences were removed.

Late mortality losses were 2 percent higher for Hereford than for Angus dams (table 1). Among the sire breed groups, only Charolais and Hereford-Angus crosses differed significantly. Only dam age was an important influence on survival from 24 hr after birth until weaning when the effect of calving difficulty was removed. When the effect of difficult births was removed, late mortality losses in calves from 2-, 3-, 4-, and ≥5-year-old dams were 9.4, 3.9, 2.7, and 1.0. Calves weaned as a percentage of those born when difficult effects are not removed are presented by age-of-dam subclasses in table 2. The combined effect of Hereford by Angus heterosis for early survival (3.0 percent) and late survival (2.9 percent) was an important influence in survival from birth to weaning (5.1 percent).

200-day weight and preweaning growth rate.—Jersey crosses were lightest at weaning and had the lowest preweaning average daily gain (ADG) (table 4). Hereford-Angus, South Devon, and Limousin crosses were similar for these traits and intermediate between the Jersey-sired calves and the heavier, more growthy Charolais and Simmental crosses. These differences in 200-day weight are due to growth potential of the calves. Additional differences associated with milk production in these crosses are under investigation.

The 20 lb advantage in 200-day weight of Angus over Hereford dams was significant, as was the 18 lb difference between straightbred Hereford and Angus. Heterosis in Hereford-Angus crosses was important for both ADG and 200-day weight. Respective values for 2-, 3-, 4-, and ≥5-year-old dams were 377, 421, 452, and 467 lb for 200-day weight and 1.52, 1.72, 1.87, and 1.92 lb/day for ADG. Steer calves gained .09 lb/day faster and were 25 lb heavier at weaning than heifer calves.

Preweaning relative growth rate (RGR) equals the percentage increase in body weight per day. RGR is of interest because it is related to difference in maturing rate and shape of growth curve. RGR was greatest for Jersey crosses, followed by Hereford-Angus crosses. RGR was similar for the other breed crosses. RGR was greater for straightbred Angus than for straightbred Herefords and for calves from Angus dams. RGR was .865 percent body weight/day for heifer and .856 for steer calves. Respective mean values for 2-, 3-, 4-, and ≥5-year-old dams were .823, .862, .878, and .877.

General.—Calving difficulty increased linearly with birth weight across and within breed groups. Higher birth weights are also associated with higher anticipated mature sizes and with increased preweaning growth potential; however, the 200-day weights of Limousin and South Devon crosses are 8 to 10 lb less than expected from their birth weights. The level of calving difficulty and the associated effects of calf mortality and lowered rebreeding performance of the cow seemingly preclude the commercial use of large sire breeds on young cows. Less obvious is how much calving difficulty can be tolerated in mature cows in order to gain the increased growth response of calves by sires from the large breeds. This study furnishes only a part of the data necessary to answer this important question in terms of total production efficiency.

Table 4.—*Breed group means for weaning traits*

Breed group[1]	No.	200-day weight	ADG	RGR[2]
		Lb	*Lb/day*	*Percent/day*
HH	128	401	1.61	.826
AA	147	419	1.74	.905
Heterosis (H by A)		18	.09	.008
HA+AH	365	428	1.76	.873
JH+JA	279	404	1.70	.915
SDH+SDA	212	428	1.74	.846
LH+LA	335	432	1.76	.843
CH+CA	342	456	1.85	.842
SH+SA	368	450	1.83	.836
H dams	1003	419	1.70	.834
A dams	1173	439	1.83	.886

[1]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[2]Relative growth rate equals percentage increase in body weight per day.

Conclusions

1. Sire breeds showed important differences for level of calving difficulty and preweaning weights and growth rates of their progeny.

a. Charolais and Simmental crosses had higher preweaning ADG and were heavier at weaning but also had larger birth weights and more calving difficulty than the other breed crosses evaluated.

b. South Devon and Limousin crosses were similar in weaning weight to Hereford-Angus crosses but were intermediate in birth weights and more like Charolais and Simmental crosses in calving difficulty.

c. Jersey crosses were lightest at birth and weaning and experienced much less calving difficulty than other crosses.

2. Calving difficulty increased linearly with birth weight across and within breed group.

a. Averaged over all age-of-dam groups, each 1 lb increase in birth weight was associated with an increased calving difficulty of .74 percent.

b. The increase in calving difficulty associated with increased birth weight was 10 times greater in 2-year-old cows than in mature cows.

3. Breed group differences in gestation length were significant but did not explain difference in birth weight or calving difficulty.

4. Hereford-Angus heterosis significantly affected birth weight (2.0 lb), 200-day weight (18 lb), ADG (.09 lb/day), and calf survival from birth to weaning (5.1 percent).

POSTWEANING GROWTH AND FEED EFFICIENCY[4]

Gerald M. Smith[5]

Postweaning growth and feed efficiency of beef steers are important components of the net efficiency of beef production systems. The wise use of available genetic resources requires that breeds representing diverse biological types be characterized for these performance traits. This section reports results on the postweaning growth and feed efficiency of 1,105 steers.

Experimental Procedure

After weaning, steers were allowed 25 to 30 days for conditioning before the start of the feeding trial, at which time they received three, 12 mg diethylstilbestrol implants. Rations for each of the 3 years are presented in ta' 5. Steers were fed free choice in outside pens approximately ' ' by 210 ft. Feed dispensed into fenceline bunks for each pen was measured with electronic scales mounted on feed trucks.

[4]Results presented here were taken from Gerald M. Smith, D. B. Laster, Larry V. Cundiff and Keith E. Gregory. Characterization of biological types of cattle. II. Postweaning growth and feed efficiency of steers. J. Anim. Sci. 43 (1976). Persons desiring a more detailed statistical evaluation are referred to this paper.

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Table 5.—*Postweaning rations*

Calf crop, year	Period	Ingredients: Corn silage	Concentrate[2]	Supplement[3]	Ration analyses[1]: Crude protein	Digestible protein	TDN	M.E.[4]
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Mcal/lb*
1970	Nov. 17 to Nov. 24	89.0	7.5	3.5	11.8	9.0	72.0	1.18
	Nov. 25 to Jan. 10	77.5	17.5	5.0	12.9	9.9	75.6	1.24
	Jan. 11 to slaughter	60.0	35.0	5.0	12.0	9.6	79.3	1.30
1971	Oct. 25 to Nov. 22	85.0	7.5	7.5	14.9	10.9	72.0	1.18
	Nov. 23 to Dec. 21	75.0	18.5	6.5	14.0	10.1	75.6	1.24
	Dec. 22 to Feb. 15	60.0	32.0	8.0	14.6	10.6	78.0	1.28
	Feb. 16 to slaughter	60.0	33.0	7.0	14.0	10.1	78.7	1.29
1972	Oct. 25 to Nov. 21	85.0	8.0	7.0	14.3	10.6	72.6	1.19
	Nov. 22 to Jan. 11	80.0	13.0	7.0	14.2	10.6	73.8	1.21
	Jan. 12 to Mar. 8	75.0	18.0	7.0	14.2	10.6	75.6	1.24
	Mar. 9 to slaughter	60.0	33.0	7.0	14.0	10.6	79.3	1.30

[1]Estimated composition based on National Research Council values for the 1970 calf crop and proximate analysis for the 1971 and 1972 calf crops; 100 percent dry matter basis.

[2]The concentrate included varying amounts of ground shelled corn, ground grain sorghum, and ground wheat.

[3]Supplement contained 42 percent crude protein. Urea was used in the supplement for the 1972 calf crop.

[4]Metabolizable energy.

Steers were allotted to pens by sire breed group, except that straightbred Hereford and Angus were penned together and Hereford-Angus reciprocal crosses were penned together. Breed groups were randomly divided into two pens each year. Steers were weighed about every 28 days. Approximately one-third of the steers in each sire-breed by dam-breed subclass were slaughtered at each of three dates. Steers were weighed and removed from the pens 2 to 3 days before slaughter. Days on feed for steers in each slaughter group were 190, 218, and 246 for 1970 steers; 169, 211, and 254 for 1971 steers; and 194, 226, and 253 for 1972 steers.

Weight and growth rates for a 180-day postweaning period were analyzed for all steers. Initial weight was calculated by average daily gain (ADG) during conditioning times 25 plus 200-day weight. Final (405-day) weight equaled ADG from the start of the feeding trial until the first slaughter date times 180 plus initial weight. ADG, relative growth rate (RGR = percentage increase in body weight per day), initial weight, and 405-day weight are presented for each sire breed group.

Efficiency of live weight gain (lb TDN per lb gain) was evaluated for three different intervals: age-constant (0 to 217 days on feed); weight-constant (530 to 1035 lb live weight); and grade-constant (0 days on feed to 5 percent ribeye fat). Five percent ribeye (*longissimus*) fat was equivalent to a marbling score of average Small which slightly exceeded minimal requirements for USDA Choice grade. A 1,035 lb live weight (without shrink) was approximately equivalent to a 635 lb carcass weight, which was near the average of Hereford-Angus crossbreds. Average time on feed was 217 days.

Results

Data are presented by sire breed group. *Comparisons of other sire breeds with Hereford and Angus should be based on the Hereford-Angus crossbreds and not the straightbreds.* Data for straightbred Hereford and Angus are presented primarily for the evaluation of Hereford-Angus heterosis. Data for Hereford and Angus dams averaged over all sire breeds are also presented for weight and growth rates.

Growth

Rank and relative differences of breed group means for weight at the beginning of the feeding trial (table 6) were similar to those for 200-day weight of these same steers and their heifer mates. After 180 days on feed, Charolais and Simmental crosses were heaviest; South Devon crosses were next heaviest; followed by Hereford-Angus and Limousin crosses; Jersey crosses weighed the least. The ranking of breed groups for 180-day ADG was essentially the same as for 405-day weight. Jersey and Limousin crosses were not significantly different for 180-day ADG. South Devon and Simmental crosses had the highest 180-day RGR, whereas Limousin and Jersey crosses had the lowest. Except for South Devon crosses and the nonsignificant reversal of Jersey and Limousin crosses, breed groups ranked the same for RGR as for ADG. Breed group ranking for preweaning and postweaning growth rates was similar for ADG (r = .82) but not for RGR (r = −.58). Breed groups that ranked high for preweaning RGR but low for postweaning RGR tended to reach puberty earlier and to fatten sooner.

Table 6.—*Breed group means for live weights and growth rates*

Breed group[1]	No.	Weight: Initial	Weight: 405-day[2]	ADG	Rel. growth rate[3]
		Pounds	*Pounds*	*Lb/day*	*Percent*
HH	66	472	924	2.51	.375
AA	84	496	926	2.38	.348
Heterosis (H by A)		22	24	.02	−.012
HA+AH	204	507	948	2.47	.350
JH+JA	132	487	899	2.29	.342
SDH+SDA	94	500	977	2.65	.374
LH+LA	173	514	944	2.38	.339
CH+CA	176	542	1036	2.73	.361
SH+SA	176	527	1021	2.76	.371
H dams	501	498	963	2.58	.369
A dams	604	520	966	2.47	.345

[1]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[2]Weight after 180 days on test.

[3]Relative growth rate is percentage change in body weight per day.

Hereford-Angus heterosis (table 6) was important for initial and 405-day weights and RGR but not for ADG during the first 180 days on feed. Steers from Angus dams were heavier at the start of feeding but had lower ADG and RGR than steers from Hereford dams. Dam breed did not affect 405-day weight.

Growth curves are shown separately by breed group in figure 1. These curves obtained by regression of pen means on days fed agree well with the analysis of individual steer weights for the 180-day interval. Simmental and Charolais crosses were the

largest, fastest growing breed groups, whereas Jersey crosses were the slowest growing. South Devon crosses were faster growing than Hereford-Angus and Limousin crosses, which had similar growth patterns. The ranking and relative differences of breed groups were similar for postweaning growth of the heifer mates to these steers.

Feed consumption and growth efficiency

Cumulative total digestible nutrients (TDN) consumed relative to days on feed is shown in figure 2. The regressions of live weight and TDN on days fed, presented in figures 1 and 2, were used to determine the relationship of TDN to live weight shown separately by breed group in figure 3. The interpretation of these feed consumption patterns is best examined in terms of efficiency of growth over different evaluation intervals.

Age-constant efficiency.—Comparisons of feed efficiency for time-constant intervals up to 250 days are provided in figure 4. Mean feed efficiencies of breed groups for the age-constant interval from 0 to 217 days on feed are summarized in table 7. Charolais crosses were significantly more efficient than Jersey

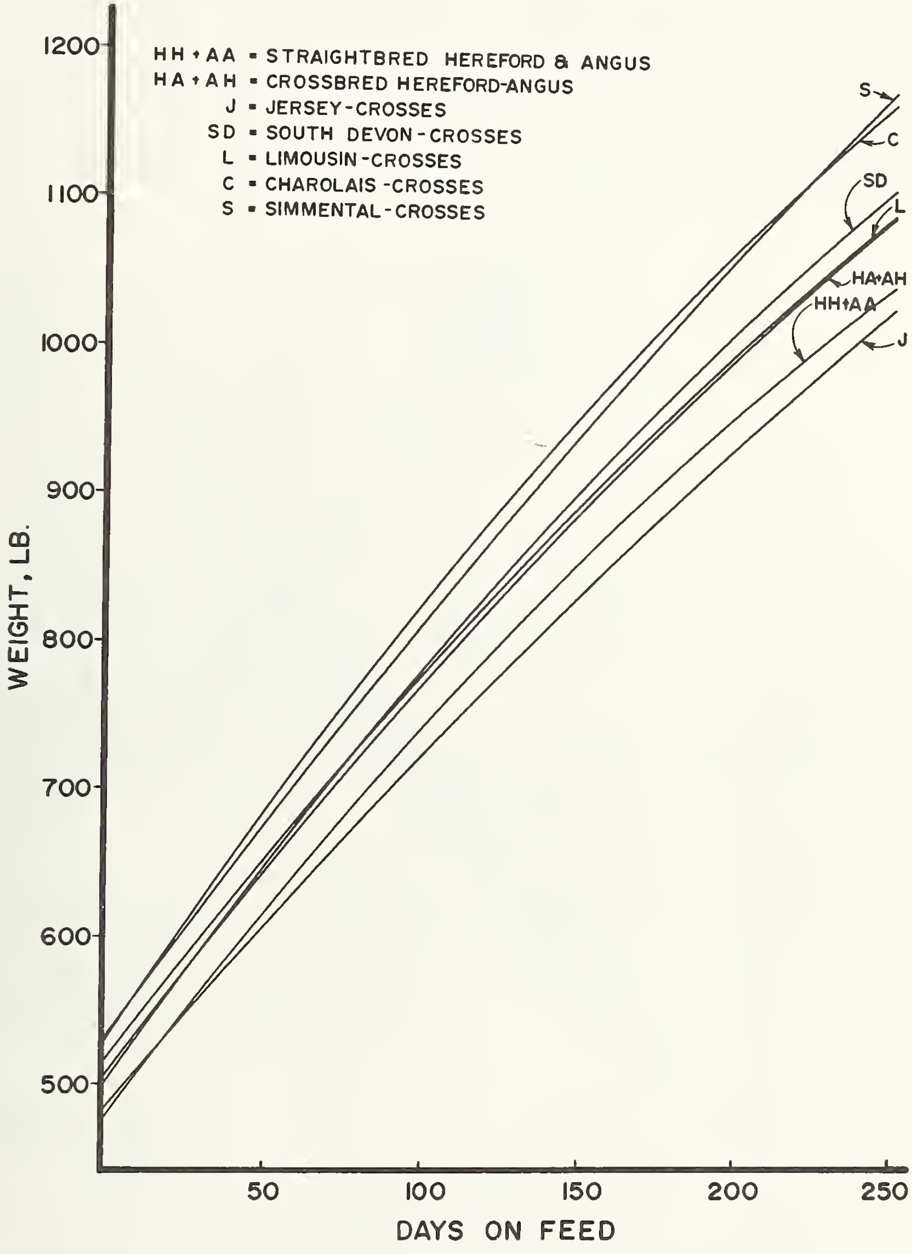

Figure 1.—Postweaning weight vs. age curves.

crosses. Evaluation of feed efficiency over an age-constant interval gives an advantage to breed groups that gain rapidly relative to weight being maintained. The fact that breed groups with the highest postweaning ADG were also the heaviest throughout the age-constant feeding period tended to reduce breed group differences in feed efficiency relative to the weight-constant interval of evaluation (table 7). Nonetheless, faster gaining breed groups tended to be more efficient than slower gaining breed groups in spite of heavier weights maintained.

Weight-constant efficiency.—Figure 5 provides comparison of feed efficiency over weight-constant intervals that began at 530 lb. When compared over a 530 to 1,035 lb interval (table 7), Jersey crosses were least efficient, and Charolais crosses were significantly more efficient than all other breed groups except Simmental crosses. Feed efficiency measured over weight-constant intervals is increased by ADG because fewer days of maintenance are required. The correlation between breed group means for feed efficiency and days on feed ($r = .94$) indicated that days on feed accounted for 88 percent of the variation in efficiency in the weight-constant interval from 530 to 1,035 lb.

Weight-constant evaluation of efficiency also favors breed groups which are less mature (that is, smaller fraction of mature size) over the interval of evaluation because of the leaner composition of their gain. The decreased efficiency of feed utilization during the feeding period observed within breed groups (fig. 4) is evidence that composition of gain influences efficiency. The number of days required to reach 1,035 lb tended to explain breed group differences in weight-constant efficiency, except that Limousin crosses—a relatively lean breed group—were more efficient and Jersey crosses—a relatively fat breed group—were less efficient than predicted

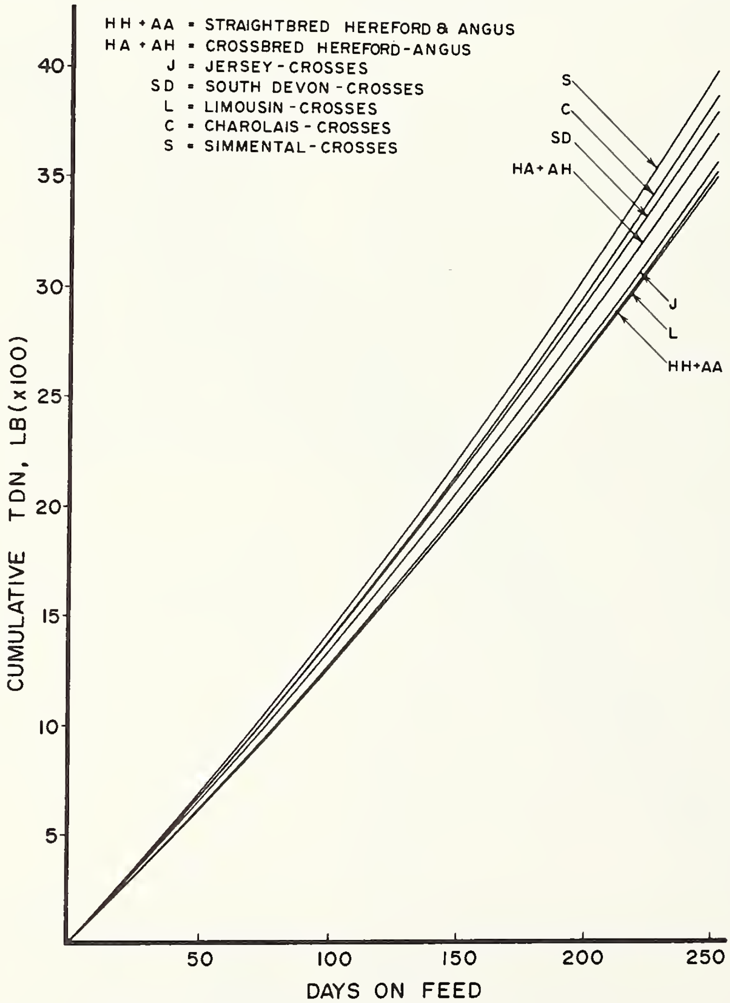

Figure 2.—Postweaning cumulative TDN vs. age curves.

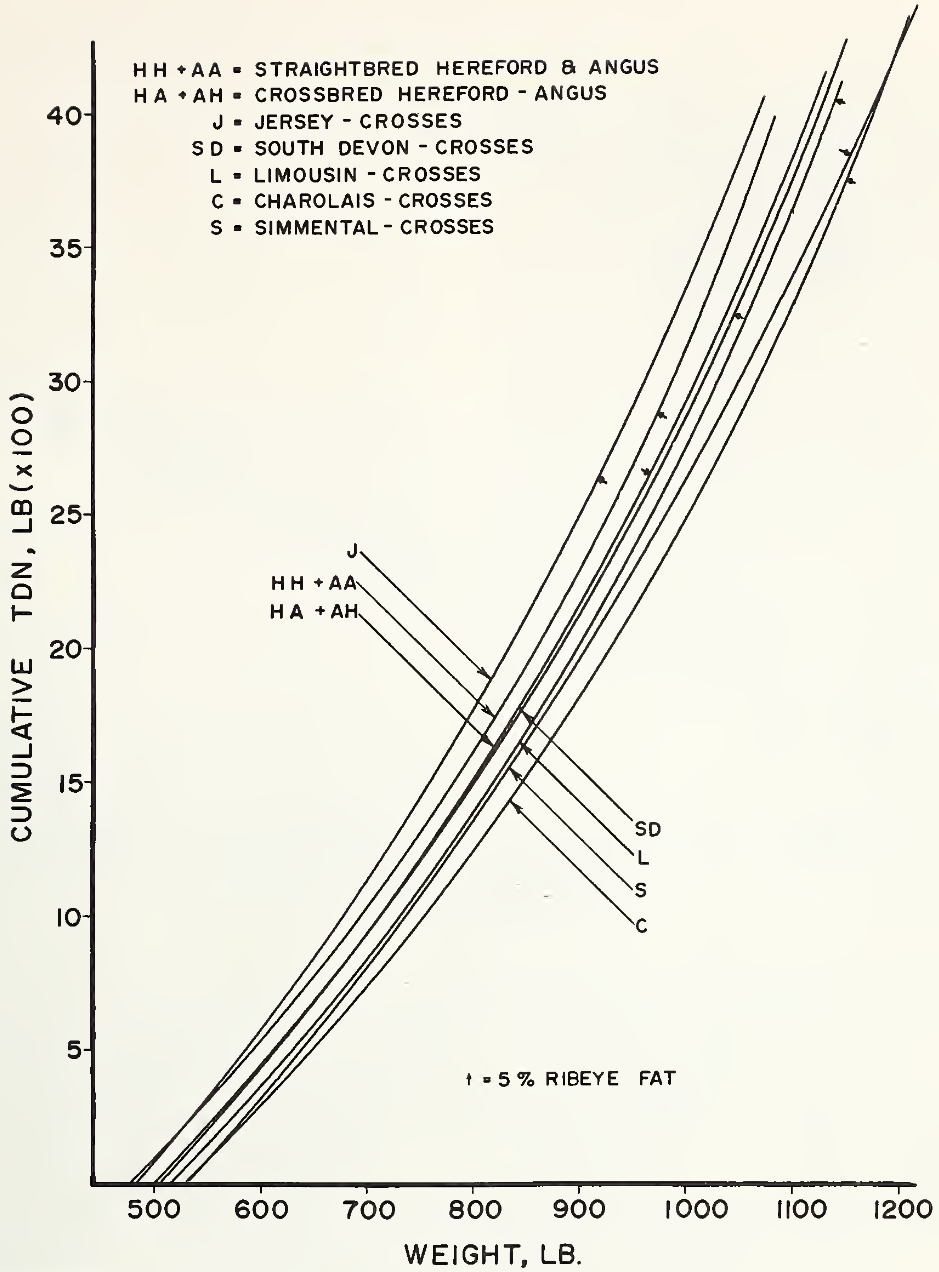

Figure 3.—Postweaning cumulative TDN vs. weight curves. Weight at 5 percent ribeye fat shown by small arrows.

from their growth rates. These deviations and the relative greater breed group differences in efficiencies over a weight-constant interval, when compared with other intervals, suggest that the fast growing breed groups were aided by the leaner composition of their gain.

Grade-constant efficiency.—Breed group differences in efficiency to a constant percentage (5 percent) of ribeye fat were less than differences over a weight-constant interval but greater than differences over an age-constant interval (table 7). The weight and number of days at which each breed group reached 5 percent ribeye fat is depicted in figures 3 and 6: Hereford and Angus straightbreds, 977 and 212; Hereford-Angus crossbreds, 968 and 187; Jersey crosses, 920 and 193; South Devon crosses, 1,030 and 209; Limousin crosses, 1,144 and 280; Charolais crosses, 1,155 and 243; and Simmental crosses, 1,157 and 241. When compared at a constant grade (fig. 6), Limousin crosses were least efficient but not significantly different from Simmental; Hereford-Angus crosses were most efficient but not

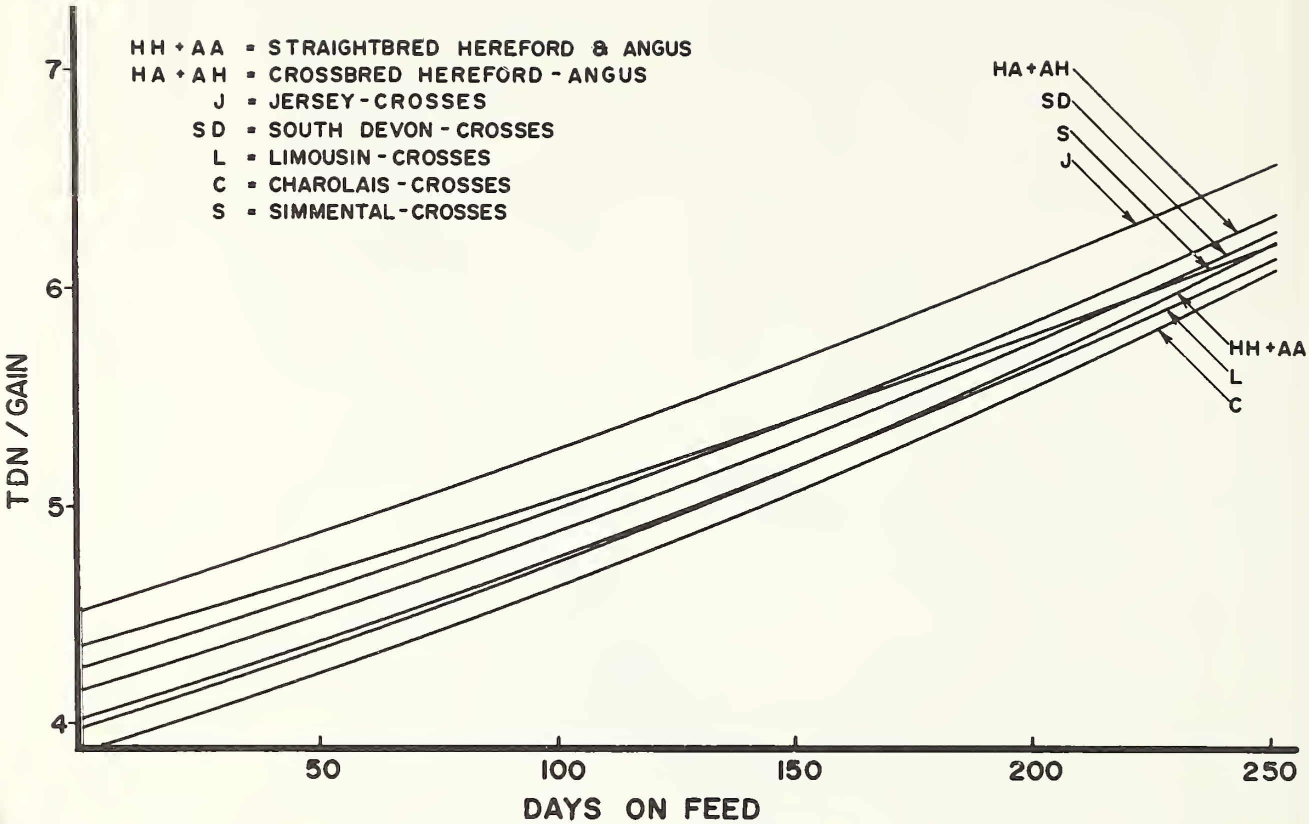

Figure 4.—Feed efficiency over constant-age intervals.

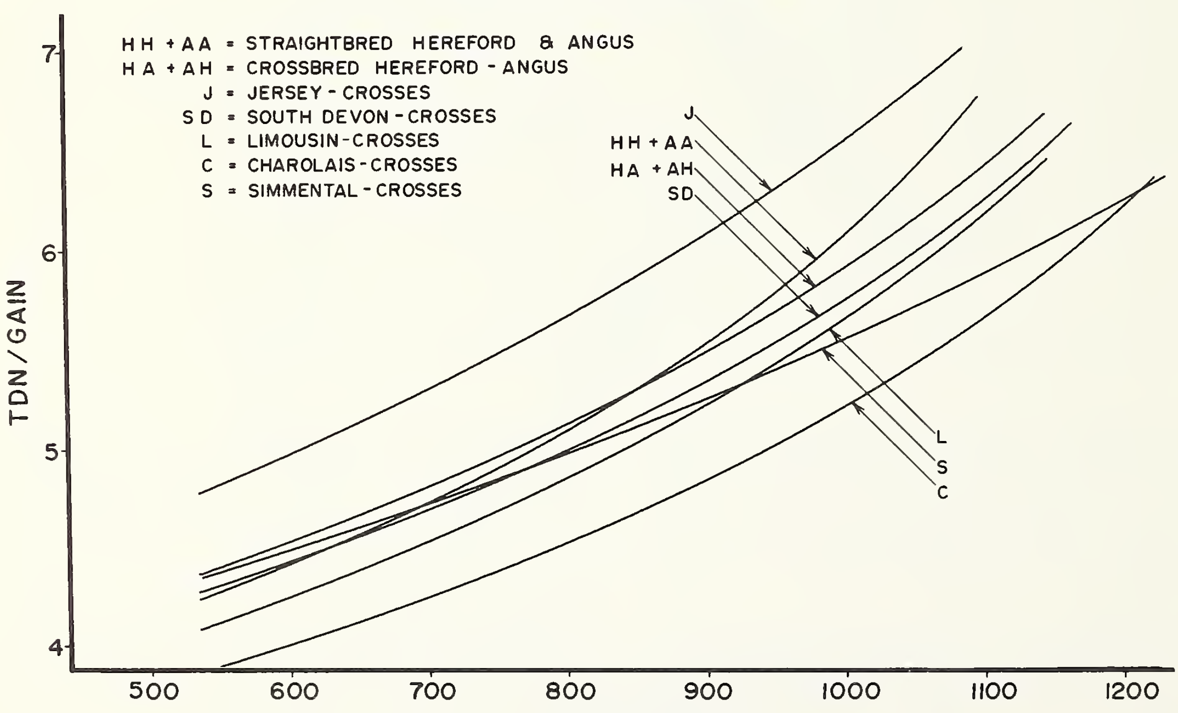

Figure 5.—Feed efficiency over constant-weight intervals.

Table 7.—*Breed group means for cumulative TDN per unit of gain for different intervals*[1]

	Interval of measurement[3]		
Breed group[2]	0 days to 217 days	530 lb to 1035 lb	0 days to 5 percent fat
HH+AA	5.83	6.37	5.77
HA+AH	5.99	6.12	5.71
JH+JA	6.24	6.79	6.03
SDH+SDA	5.90	5.96	5.82
LH+LA	5.78	5.87	6.44
CH+CA	5.70	5.39	5.98
SH+SA	5.91	5.69	6.11

[1]TDN per unit gain (lb/lb) can be converted to approximate metabolizable energy per unit gain (Mcal/lb) by multiplying by 1.64.

[2]H=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental; sire breed is first and dam breed is second.

[3]Intervals begin after a 25- to 30-day conditioning period (0 days) or at 530 lb live weight and end after 217 days on feed, 1035 lb live weight, or 5 percent ribeye fat.

significantly different from South Devon, Charolais, or Jersey crossbreds.

Breed group differences in grade-constant efficiency tended not to be associated with measures of size or absolute growth rate over age-constant intervals; however, the number of days required to reach 5 percent ribeye fat accounted for 74 percent of the breed group variation in grade-constant efficiency. Grade-constant efficiency would be improved by lowered maintenance costs associated with earlier maturing cattle (fewer days of maintenance) or lighter average weight to be maintained, or both. Maturing rate and average weight over a maturity-constant interval tend to be negatively associated with mature size; however, the total amount of gain over a maturity-constant interval would be greater for breed groups of larger mature size. Any propensity to deposit ribeye fat faster than cattle with similar maturing rate (for body weight) would also improve the grade-constant efficiency of a breed group.

Heterosis for feed efficiency.—Hereford-Angus heterosis for efficiency of feed utilization was −2.8, 3.8, and 0.9 percent for age-, weight-and grade-constant intervals (table 7); none of these differences were significant. Previous results have shown essentially no heterosis for feed efficiency over age-constant intervals. For age-constant intervals, Hereford-Angus crossbreds are at a disadvantage because of their heavier maintenance weight and fatter composition of gain compared with straightbreds. Because the carcass composition of straightbred and crossbred Hereford-Angus is nearly the same at constant weights, Hereford-Angus heterosis for efficiency over a weight-constant interval tends to be independent of composition of gain and

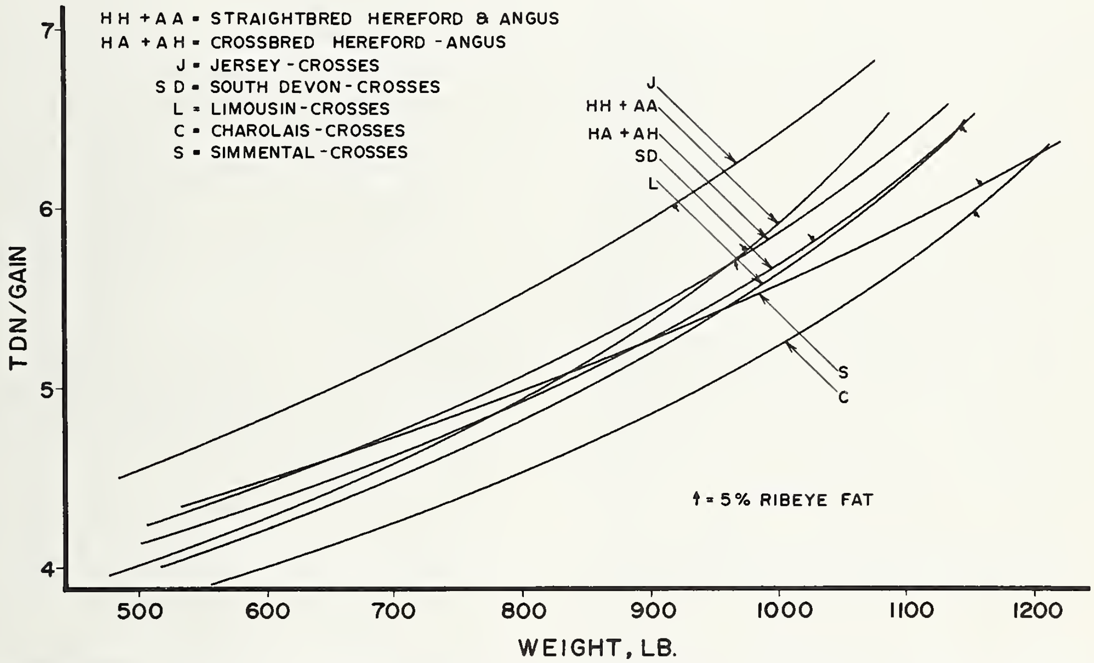

Figure 6.—Feed efficiency over intervals beginning at 0 days on feed and ending at various weight end points. Weight at 5 percent ribeye fat shown by small arrows.

weight maintained. Evaluation over the constant starting age to 5 percent ribeye fat (constant-grade) interval (0 days to 977 lb for straightbred, and 0 days to 968 lb for crossbreds) averaged out the difference between weight- and age-constant intervals.

General.—Gross feed efficiency is a function of feed intake, maintenance weight, composition of gain and of weight being maintained, environment, physiological age, and intrinsic efficiencies associated with digestion, absorption, or cellular utilization of metabolites. Information is not available to differentiate among the causal effects in gross efficiencies; however, examining the gross efficiency over different intervals offers some insight into the different factors. Weight-constant comparisons show that growth rate or intake above maintenance is an important component of gross efficiency. The marked advantage of slower maturing breed groups over weight-constant intervals suggests that gross efficiency is greater for the synthesis of lean than for fat. The breed group differences in efficiency to a grade-constant slaughter weight suggest that genetic variation may exist for intrinsic efficiency or in relative rates of fat deposition.

The correlation between feed efficiency in the age- and weight-constant intervals was high ($r = .94$). Correlations between measures of growth and maturing rates and carcass composition with age- and weight-constant efficiencies reveal that feed efficiency was greater in both intervals for the fast gaining, slow maturing, lean breed groups. However, the variation between breed group means was much greater in the weight-constant (range of breed group means = 23 percent)[6] than in the age-constant (range = 9 percent) interval.

In the weight-constant interval, total feed requirements for maintenance are reduced for more rapidly gaining groups by a substantial reduction in days on feed. In the age-constant interval, more rapidly gaining groups were more efficient, but the advanage was tempered by a greater maintenance requirement associated with large size throughout the time-constant feeding period. Hence, weight-constant evaluation maximizes the advantage associated with maturity effects. The variation between breed group means in grade-constant efficiency (range = 12 percent) was comparable to that for age-constant efficiency but lower than that for weight-constant efficiency. Knowledge of body weights and growth rates would have revealed most of the breed-group differences in age-and weight-constant efficiencies but not in efficiency at a constant grade.

[6]Range of breed group means calculated by dividing the difference between the largest and smallest value by the mean.

Conclusions

1. Important differences were found among sire breeds for 405-day weight (range of breed group means = 14 percent), postweaning average daily gain (ADG) (range = 19 percent) and postweaning relative growth rate (RGR) (range = 10 percent).
   a. Charolais and Simmental crosses, followed by South Devon crosses, were the largest, fastest gaining breed groups.
   b. Hereford-Angus and Limousin crosses were similar in ADG and 405-day weight.
   c. Jersey crosses were the smallest, slowest growing steers.
   d. Breed group rankings were similar for ADG and RGR.
2. Breed group differences in feed efficiency were large (range = 23 percent) over the weight-constant interval of evaluation but reduced over age-constant (range = 9 percent) and grade-constant (range = 12 percent) intervals.
   a. For weight-constant (530 to 1,035 lb) evaluation, Jersey crosses were least efficient, and Charolais crosses were significantly more efficient than all other breed groups except Simmental crosses.
   b. For age-constant (0 to 217 days on feed) evaluation, Charolais crosses were significantly more efficient than Jersey crosses.
   c. For grade-constant (0 days to 5 percent ribeye fat) evaluation, Limousin crosses were least efficient but not significantly different from Simmental crosses; Hereford-Angus crosses were most efficient but not significantly different from South Devon, Charolais, or Jersey crosses.
3. Body weights and growth rates accounted for most of the breed-group differences in age- and weight-constant efficiencies but not in efficiency at a constant grade.
4. Hereford-Angus heterosis for efficiency over a weight-constant interval tends to be independent of both composition of gain and weight maintained. Although not statistically significant in this study, the 3.8 percent heterosis is of considerable interest and warrants more critical examination.

CARCASS COMPOSITION, QUALITY, AND PALATABILITY[7]

Robert M. Koch[8] and Michael E. Dikeman[9]

Carcass characteristics of the 14 breed groups in Cycle I of the germ plasm evaluation program are reported in this section. These breed groups, though not a random sample of the cattle population, are expected to indicate in a general way the genetic tendencies that would be found in a broad sample of cattle breeds and may offer insight to genetic variation within breeds.

Experimental Procedure

Steer carcasses from 3 years' calf crops were evaluated. Each year one-third of the steers were slaughtered at each of three slaughter dates spaced about 1 month apart. Slaughter at three dates provided a range in weight and fatness for each of the breed groups. Average age at the start of feeding was 240 days, and the average number of days on feed was 217. Slaughter was carried out at a commercial packing plant. After a 24 hr chill, carcasses were evaluated for conformation, maturity, marbling, color, texture, firmness, and USDA quality and yield grades. The right side of each carcass was trucked to Kansas State University for processing to obtain detailed cutout information and taste panel evaluation. The round, rib, loin, and chuck were processed into closely trimmed boneless roasts (including steak meat), and lean trim, except for a small amount of bone left in short loin and rib roasts. Fat was trimmed to no more than 0.3 inch on any surface. Lean from the flank, plate, brisket, and shank was added to the lean trim from the four major cuts. Chemical analysis of the lean trim in each carcass was used to adjust total lean trim to a 25 percent chemical fat basis. The sum of roasts and lean trim was called retail product.

A steak from the 12th rib of each carcass was used to determine intramuscular fat of the ribeye (*longissimus*) muscle. Steaks at the 10th and 11th ribs from four representative carcasses of each breed group at each slaughter date were frozen and later used in a taste panel evaluation of tenderness, flavor, juiciness, and overall acceptability.

Genetic merit of animals in each breed-slaughter group was expected to be similar except for sampling variation. Therefore, change in carcass composition of the breed group average from one slaughter date to the next provided a method of adjusting breed group means to three alternative endpoints for comparison: (1) constant age, (2) constant weight, and (3) constant percentage of fat in the ribeye muscle. The constant age used was 457 days (240 days average at start plus 217 days average on feed). The constant weight selected was a hot carcass weight of 635 lb, which was close to the average of Hereford-Angus crosses and approximates the carcass weight expected from a 1,000 lb steer. The amount of fat in the ribeye muscle selected as a base of comparison was 5 percent because this approximated the minimum marbling required for A maturity carcasses to grade USDA Choice. Each of the breed group means was adjusted by the linear change observed in the various traits during the last 60 days on feed relative to the change in the base trait of comparison, for example, carcass weight, days on feed, or fat in the ribeye muscle. This method of adjustment estimates values that would be obtained if all animals in a breed group had been fed for fewer or more days until the average of the breed group reached the endpoint selected.

Results

Breed group means for composition traits are compared at a common age (457 days) in table 8, at a common carcass weight (635 lb) in table 9, and at 5 percent fat in the ribeye muscle in table 10. Adjusted weights for retail product, fat trim, and bone were expressed as percentages for convenient comparison. *Comparisons of Hereford and Angus sires with other sire breeds should be based on the Hereford-Angus crossbred groups and not the straightbreds.* Significant heterosis is expected in growth traits of all breed crosses although composition did not seem to exhibit heterosis in Hereford-Angus contrasts.

Slaughter and hot carcass weight.—Slaughter weight was based on weight out of the feedlot in the morning before feeding with a 4 percent pencil shrink. Differences in slaughter and carcass weights at a constant age (table 8) indicate significant differences in average growth rate. Carcass weight multiplied by the percentage of carcass that is retail product, fat trim, or bone indicates significant differences in growth rate of these tissues.

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[7]Results presented here were taken from R. M. Koch, M. E. Dikeman, D. M. Allen, M. May, J. D. Crouse, and D. R. Campion. Characterization of biological types of cattle. III. Carcass composition, quality and palatability. J. Anim. Sci. 43(1976).

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Table 8.—*Carcass composition when breed group means were adjusted to a starting age of 240 days and 217 days on feed*

Trait	Breed group[1] HH AA	AH HA	JH JA	SDH SDA	LH LA	CH CA	SH SA	Avg
Number of animals	69	97	53	44	82	78	87	510
	85	113	81	50	95	99	88	611
Slaughter ....pounds..	971	1003	958	1012	1009	1092	1080	1018
weight	968	999	945	1037	1019	1082	1065	1016
Average	970	1001	951	1024	1014	1087	1072	1017
Hot carcass ....pounds..	610	637	595	645	645	690	674	642
weight	619	637	592	667	659	692	673	648
Average	614	637	593	656	652	691	673	645
Bone ....percent[2]..	12.7	12.1	12.7	12.6	12.7	13.3	13.8	12.9
	11.7	11.8	12.1	12.1	12.3	12.7	13.0	12.3
Average	12.2	12.0	12.4	12.3	12.5	13.0	13.4	12.6
Retail ....percent[2]..	67.4	66.1	65.1	66.9	71.9	71.9	71.0	68.7
product	65.6	65.0	64.7	67.2	71.4	70.4	69.4	67.8
Average	66.5	65.5	64.9	67.0	71.7	71.2	70.2	68.2
Fat ....percent[2 3]..	19.9	21.8	22.2	20.6	15.4	14.8	15.3	18.4
trim	22.7	23.2	23.2	20.7	16.2	16.9	17.6	20.0
Average	21.3	22.5	22.7	20.6	15.8	15.8	16.4	19.2
Kidney ....percent[2]..	3.1	3.7	5.7	4.3	3.7	3.7	3.6	3.9
and pelvic fat	3.8	3.4	5.7	4.4	4.0	4.0	4.2	4.2
Average	3.5	3.5	5.7	4.3	3.8	3.8	3.9	4.1
Fat thickness, ...inch..	0.52	0.63	0.42	0.46	0.40	0.35	0.37	0.45
at 12th rib	.66	.67	.51	.52	.43	.43	.43	.52
Average	.59	.65	.46	.49	.41	.39	.40	.48
Ribeye ......square inch..	10.7	11.2	10.6	11.4	12.7	12.5	12.2	11.6
area	11.0	11.1	10.7	11.8	12.9	13.0	12.2	11.8
Average	10.8	11.1	10.6	11.6	12.8	12.7	12.2	11.7
Yield grade	3.1	3.3	3.4	3.1	2.4	2.4	2.5	2.9
	3.4	3.4	3.4	3.1	2.5	2.6	2.7	3.0
Average	3.2	3.4	3.4	3.1	2.4	2.5	2.6	3.0
Ribeye ....percent..	5.0	6.2	6.0	5.2	3.6	4.3	4.4	5.0
fat	6.9	5.7	7.4	5.9	4.3	5.1	5.1	5.8
Average	6.0	6.0	6.7	5.6	3.9	4.7	4.8	5.4

[1]H=Hereford; A=Angus; J=Jersey; SD=South Devon; L=Limousin; C=Charolais; S=Simmental. Breed of sire is first and breed of dam is second.

[2]Percentage of total retail product, fat trim, and bone.

[3]Fat trim includes kidney and pelvic fat.

Dressing percentage (table 9) did not differ significantly even though hide weight and fatness differed significantly among breed groups.

Bone.—Bone percentage included major tendons and excised ligaments. The fraction of total bone left in the short loin and the partially boneless rib was estimated as .157. Therefore total bone can be approximated by dividing bone values in the tables by .843 and the corresponding change deducted from retail product to obtain boneless retail product.

Differences in percentage of bone were small on a weight constant basis (table 9). There was a tendency for the larger breeds to have a higher proportion of bone.

Retail product.—If retail product percentages in tables 8, 9, and 10 are plotted against hot carcass weight, several interesting points become evident (fig. 7). First, as cattle in each breed group are fed to higher weights, the percentage of retail product declines. Counter to this trend, because of days on feed, is a genetic trend associated with the age constant breed group means. The change associated with the age constant means, table 8 and plotted as the solid line in figure 7, suggests a strong genetic

tendency for groups that grow more rapidly to have a higher percentage of retail product than slower growing types.

Differences in composition were greatest when comparisons of breed groups were made at a constant carcass weight and smallest at a constant percentage of fat in the ribeye muscle. Charolais, Limousin, and Simmental crosses were significantly higher in retail product percentage and Jersey crosses were lowest. South Devon crosses were intermediate.

Fat characteristics.—Fat trim included the kidney knob and pelvic fat. Because varation in bone was relatively small, differences in fat trim percentage is essentially the opposite picture observed for retail product. Fat trim percentage increased in all breeds as weight from feeding increased. The genetic trend based on breed group means at a constant age was downward, that is, faster growing breed groups had lower fat percentages. Jersey crosses and Hereford and Angus straightbreds and crossbreds had the highest while Charolais, Limousin, and Simmental crosses had the lowest fat trim percentages. South Devon crosses again were intermediate. Fat trim is the major variable influencing composition that can be affected by producers through breeding, feeding, or management practices.

Kidney and pelvic fat was highest in Jersey crosses and lowest in Hereford-Angus types than other breed groups at all endpoints compared.

Table 9.—*Carcass composition when breed group means were adjusted to a hot carcass weight of 635 pounds*

Trait	Breed group[1]							
	HH AA	AH HA	JH JA	SDH SDA	LH LA	CH CA	SH SA	Average
Hide ---pounds	90	80	73	78	78	79	89	81
	73	81	66	72	73	76	80	74
Average	82	81	70	75	76	77	84	78
Dressed yield ---percent	63.0	63.5	62.8	63.5	64.0	63.0	61.8	63.1
	64.2	63.7	62.5	64.1	64.4	63.3	63.0	63.6
Average	63.6	63.6	62.7	63.8	64.2	63.1	62.4	63.4
Bone ---percent[2]	12.3	12.1	12.3	12.7	12.9	13.8	14.2	12.9
	11.5	11.8	11.8	12.5	12.7	13.3	13.3	12.4
Average	11.9	12.0	12.0	12.6	12.8	13.6	13.8	12.6
Retail product ---percent[2]	66.5	66.1	63.6	67.1	72.4	73.1	71.8	68.6
	64.9	65.0	63.0	68.7	72.4	71.9	70.2	68.0
Average	65.7	65.6	63.3	67.9	72.4	72.5	71.0	68.3
Fat trim ---percent[2 3]	21.2	21.8	24.2	20.2	14.8	13.1	14.0	18.5
	23.7	23.1	25.2	18.8	15.0	14.8	16.5	19.6
Average	22.5	22.4	24.7	19.5	14.9	13.9	15.2	19.0
Kidney and pelvic fat ---percent[2]	3.3	3.7	5.8	4.3	3.5	3.4	3.5	3.9
	3.9	3.4	6.2	4.0	3.9	3.6	4.0	4.1
Average	3.6	3.5	6.0	4.1	3.7	3.5	3.7	4.0
Fat thickness at 12th rib ---inch	0.56	0.62	0.52	0.45	0.38	0.28	0.32	0.45
	.69	.66	.56	.44	.39	.32	.39	.49
Average	.63	.64	.54	.44	.38	.30	.36	.47
Ribeye area ---square inch	10.8	11.1	10.6	11.4	12.6	12.1	12.0	11.5
	11.0	11.1	10.9	11.8	12.8	12.5	12.1	11.8
Average	10.9	11.1	10.8	11.6	12.7	12.3	12.0	11.6
Yield grade	3.2	3.3	3.6	3.1	2.3	2.2	2.3	2.9
	3.5	3.4	3.7	2.8	2.4	2.3	2.5	2.9
Average	3.4	3.4	3.7	3.0	2.3	2.2	2.4	2.9
Ribeye fat ---percent	5.5	6.2	7.1	5.0	3.4	3.1	4.0	4.9
	7.6	5.7	9.3	5.2	3.8	4.1	4.6	5.8
Average	6.6	6.0	8.2	5.1	3.6	3.6	4.3	5.3

[1]H=Hereford; A=Angus; J=Jersey; SD=South Devon; L=Limousin; C=Charolais; S=Simmental. Breed of sire is first and breed of dam is second.

[2]Percentage of total retail product, fat trim, and bone.

[3]Fat trim includes kidney and pelvic fat.

Table 10.—*Carcass composition based on breed group means adjusted to 5 percent fat in the ribeye muscle*

Trait	Breed group[1] HH AA	AH HA	JH JA	SDH SDA	LH LA	CH CA	SH SA	Average
Slaughter ______pounds__	970	933	913	1001	1116	1140	1169	1034
weight	915	928	860	981	1072	1076	1047	983
Average ____________	942	931	886	992	1094	1107	1109	1008
Hot carcass _____pounds__	609	584	560	637	713	721	735	651
weight	577	583	539	628	696	687	663	625
Average ____________	593	584	550	632	704	704	699	638
Bone __________percent[2]__	12.7	12.6	13.2	12.6	11.8	13.1	13.2	12.8
	12.4	12.6	12.5	12.6	11.9	12.7	13.1	12.7
Average ____________	12.5	12.6	12.9	12.6	11.9	12.9	13.1	12.8
Retail _________percent[2]__	67.5	67.0	66.5	67.1	69.1	71.3	69.8	68.6
product	67.5	67.1	67.2	69.1	70.1	70.6	69.6	69.0
Average ____________	67.5	67.1	66.9	68.1	69.6	70.9	69.7	68.8
Fat __________percent[2] [3]__	19.8	20.4	20.3	20.3	19.1	15.6	17.0	18.5
trim	20.6	20.2	20.3	18.3	18.0	16.7	17.3	18.4
Average ____________	20.2	20.3	20.3	19.2	18.5	16.2	17.2	18.4
Kidney ________percent[2]__	3.1	3.6	5.7	4.3	4.6	3.8	3.8	3.9
and pelvic fat	3.5	2.9	5.0	3.8	4.3	3.9	4.2	3.9
Average ____________	3.3	3.2	5.3	4.1	4.4	3.8	4.0	3.9
Fat thickness, ______inch__	0.52	0.54	0.33	0.45	0.53	0.39	0.43	0.45
at 12th rib	.58	.54	.45	.42	.49	.42	.42	.46
Average ____________	.55	.54	.39	.44	.51	.40	.43	.46
Ribeye ______square inch__	10.7	10.8	10.5	11.4	12.9	12.7	12.5	11.6
area	10.6	10.8	10.4	11.8	13.0	13.0	12.2	11.6
Average ____________	10.7	10.8	10.4	11.6	13.0	12.8	12.3	11.6
Yield grade _____________	3.1	3.1	3.1	3.1	3.0	2.6	2.8	2.9
	3.2	3.1	3.1	2.8	2.8	2.5	2.7	2.8
Average ____________	3.2	3.1	3.1	2.9	2.9	2.6	2.7	2.9

[1]H=Hereford; A=Angus; J=Jersey; SD=South Devon; L=Limousin; C=Charolais; S=Simmental. Breed of sire is first and breed of dam is second.

[2]Percentage of total retail product, fat trim, and bone.

[3]Fat trim includes kidney and pelvic fat.

Fat thickness was closely related to amount of fat trim among the breed group means when all were adjusted to the same carcass weight, although Jersey crosses had a lower fat thickness than might be expected from the total amount of fat trim.

Ribeye area.—Ribeye area has often been used as an indicator of lean muscle. Because it does not increase proportionately with total carcass weight, comparisons should be made at a common carcass weight as in table 9. Breed groups with larger ribeye areas had higher percentages of retail product. Limousin cross carcasses had the largest area, exceeding Charolais crosses even though retail product percentage was similar for the two breed groups.

Yield grade.—Yield grade was calculated from the formula prescribed by USDA (1965) beef grading standards. Yield grade means were inversely related to percentage of retail product.

Ribeye fat percentage.—Intramuscular fat in the ribeye is a chemical evaluation of marbling and is of considerable economic importance because marbling is the most important factor determining USDA quality grade. Breed crosses differed significantly in percentage of intramuscular fat percentage when compared at a common age or weight. Jersey crosses were significantly higher than other breed crosses and were followed in rank by Hereford-Angus, South Devon, Simmental, Charolais, or Limousin. Percentage of ribeye fat plotted against hot carcass weight (fig. 8) shows breed crosses differed by 150 lb in the average carcass weight when they reached 5 percent fat in the ribeye. Interestingly, Charolais,

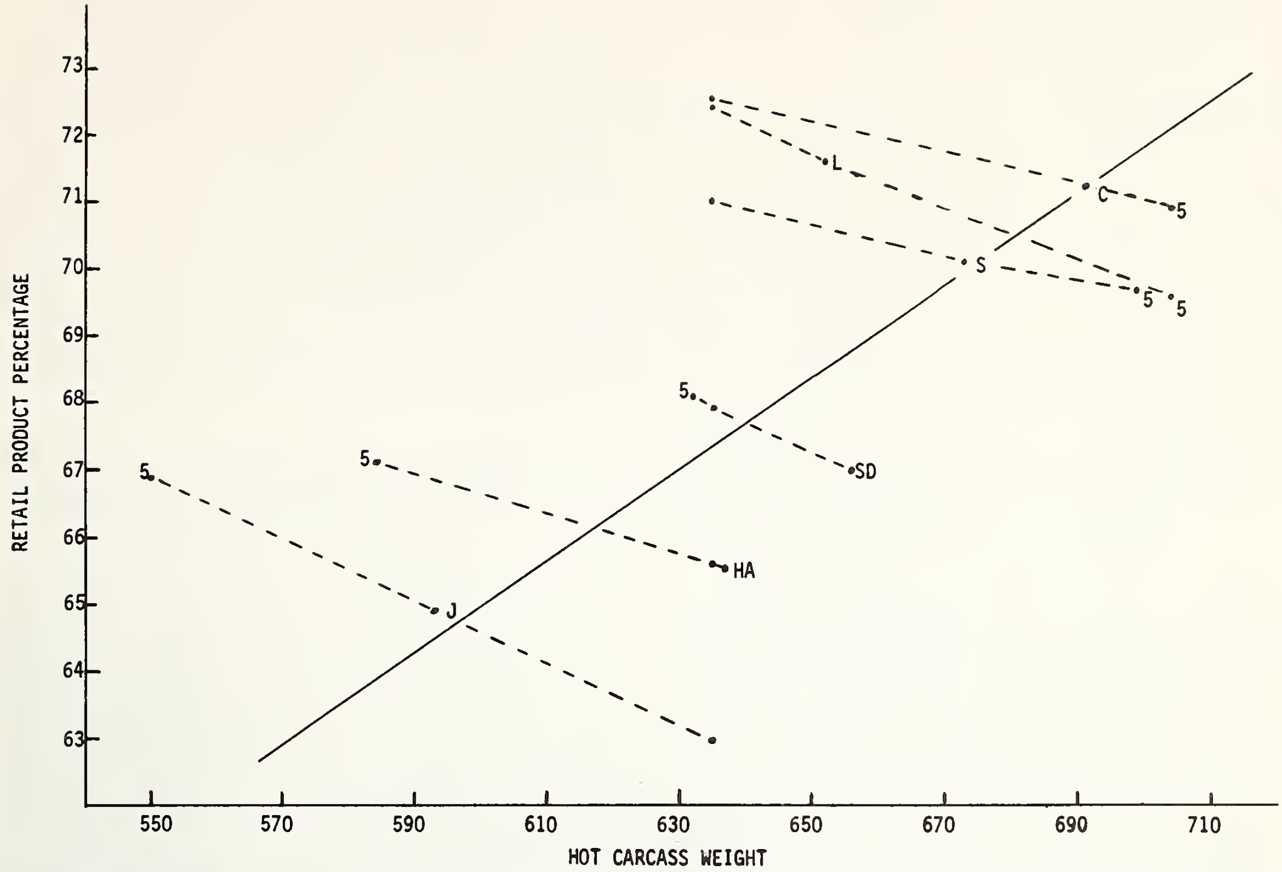

Figure 7.—Retail product percentage relative to hot carcass weight when breed groups are fed varying lengths of time to reach (1) a hot carcass weight of 635 lb, (2) a constant age of 457 days (marked by initial of sire breed), and (3) 5 percent fat in the ribeye (marked 5). Dotted lines connect breed group means at the three endpoints. The solid line is the regression of age constant means for retail product percentage on hot carcass weight.

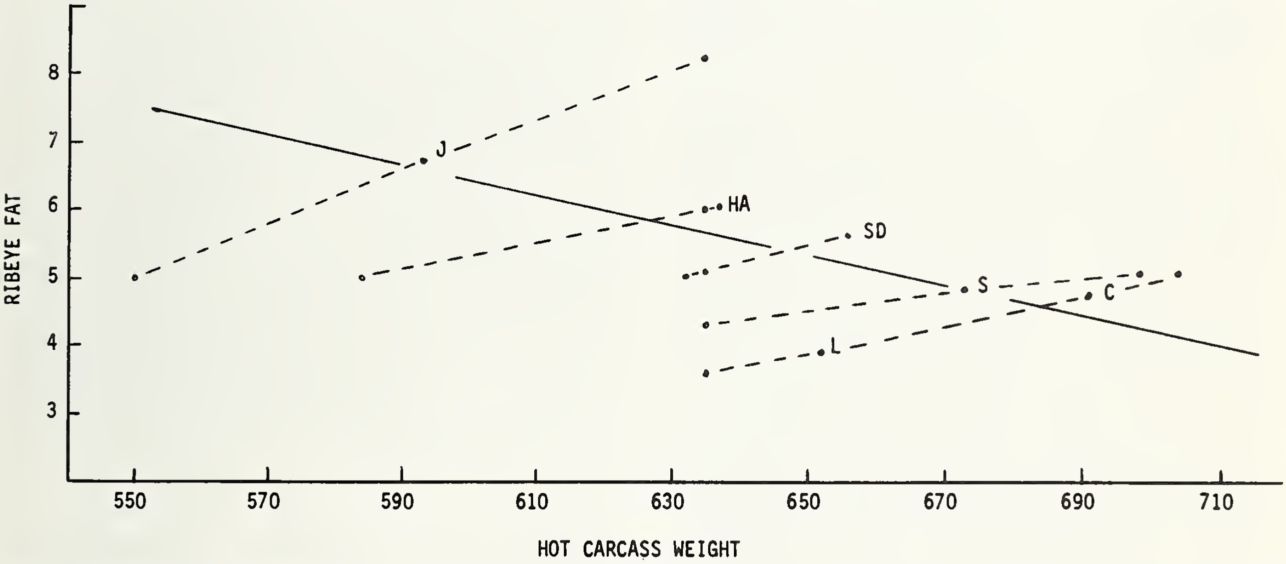

Figure 8.—Ribeye fat percentage relative to hot carcass weight when breed groups are fed to (1) a hot carcass weight of 635 lb, (2) a constant age of 457 days (marked by the initial of sire breed), and (3) 5 percent fat in the ribeye. Dotted lines connect breed group means at the three endpoints. The solid line is the regression of age constant means for ribeye fat percentage on hot carcass weight.

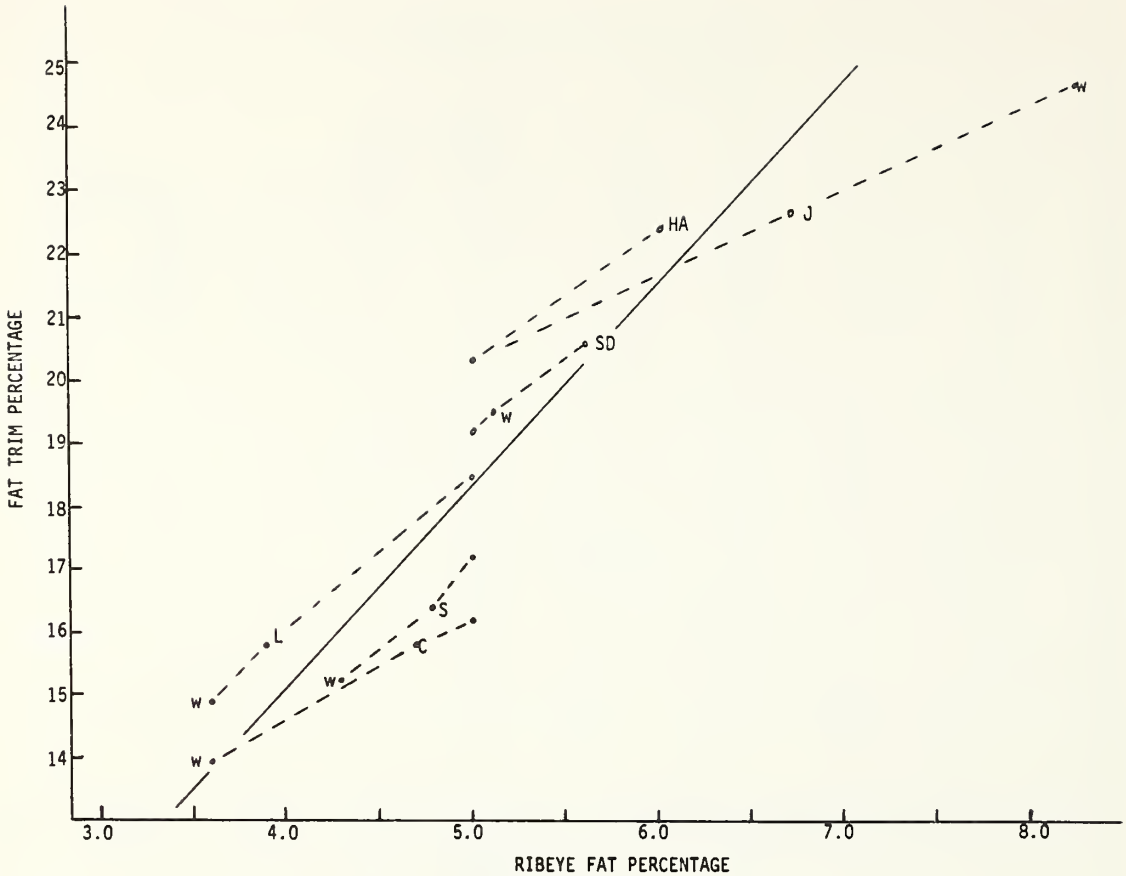

Figure 9.—Change in fat trim percentage relative to ribeye fat percentage when breed groups are fed to (1) a hot carcass weight of 635 lb (marked by W), (2) a constant age of 457 days (marked by the initial of the sire breed), and (3) 5 percent fat in the ribeye. Dotted lines connect breed group means at the three endpoints. The solid line is the regression of age constant means for fat trim percentage on ribeye fat percentage.

Limousin, and Simmental were quite similar in the estimated slaughter and carcass weight when they had 5 percent fat in the ribeye.

If percentage of fat trim is compared to ribeye fat (fig. 9), also evident is an increased intramuscular fat associated with an increased percentage of total fat trim. The trend showed a strong positive from the effect of feeding and the genetic trend of age constant breed group means.

Quality grade, marbling scores, and conformation. —Quality grade (table 11) was based on separate evaluation of conformation and on characteristics that indicate palatability, including marbling, maturity, color, texture, and firmness of lean. All of these cattle were young and grade was determined primarily by marbling and conformation. Straightbred Angus and Angus crosses graded higher than other breed groups.

Conformation (thickness and fullness in relation to length) was significantly higher in straightbred Angus, Limousin, and Charolais crosses and lower in Jersey crosses than the other breed groups.

Marbling scores were closely related to ribeye chemical fat percentage and significantly higher in straightbred Angus and in Jersey crosses than in other breed groups. Limousin crosses had the lowest marbling scores. Lower average quality grades relative to marbling for most breed groups were due to adjustment for conformation and to differences in scaling of marbling and quality grade. Prime and Choice grades each include three degrees of marbling whereas Good and Standard include only one and one-half degrees of marbling.[10] Distribution of carcasses by grades within the breed groups is shown in table 12.

[10]Degrees of marbling for each quality grade: Prime = Abundant, Moderately abundant, Slightly abundant; Choice = Moderate, Modest, Small; Good = Slight, Traces plus; Standard = Average and Traces minus, Practically devoid, USDA (1965).

Palatability.—Taste panel evaluation was made on a subset of 496 carcasses and samples scored on a desirability scale from 1 to 9. All breed group means (table 11) were well above the minimum levels of acceptability. Differences among sire breed group means for taste panel tenderness and acceptability were small but statistically significant. Jersey and South Devon crosses were more tender and Limousin and Simmental crosses were less tender than other breed crosses. Within breed groups, data from the three slaughter groups (not shown here), indicated there was essentially no change in average taste panel tenderness and acceptability scores. The average changes observed were —.0015 and —.0001 units per day, respectively. At the same time, average marbling scores increased .025 per day. Data adjusted for differences in age and time on feed indicated that taste panel tenderness scores increased .065 units per marbling score, which is comparable to an increase of one taste panel score per 15 marbling units. Thus, among breed groups of similar age and time on feed, those that had more marbling also had slightly higher taste panel scores; within breed groups, the increased marbling from time on feed seemed to just about compensate for decreased tenderness associated with increased age.

Flavor and juiciness scores did not differ significantly among the breed groups even though their marbling was significantly different.

Table 11.—*Quality and palatability for breed group means adjusted to a starting age of 240 days and 217 days on feed*

	Breed group[1]							
	HH	AH	JH	SDH	LH	CH	SH	Avg
Trait	AA	HA	JA	SDA	LA	CA	SA	Avg
Quality grade[2]	9.2	10.0	9.6	9.6	8.6	9.0	9.0	9.3
	10.4	9.7	10.3	10.2	9.0	9.8	9.4	9.8
Average	9.8	9.9	9.9	9.9	8.8	9.4	9.2	9.6
Marbling score[3]	10.1	12.2	13.0	11.2	8.9	10.0	9.8	10.8
	13.1	11.5	14.6	12.5	10.0	11.6	11.1	12.0
Average	11.6	11.9	13.8	11.8	9.5	10.8	10.4	11.4
Conformation[2]	11.1	11.7	9.1	11.0	11.9	11.9	11.4	11.2
	12.0	11.8	9.5	11.4	12.4	12.6	11.7	11.6
Average	11.6	11.7	9.3	11.2	12.2	12.5	11.6	11.4
Taste panel evaluation								
Tenderness[4]	7.3	7.5	7.6	7.3	6.8	7.2	6.6	7.2
	7.3	7.3	7.4	7.6	7.2	7.5	7.2	7.4
Average	7.3	7.4	7.5	7.5	7.0	7.4	6.9	7.3
Flavor[4]	7.4	7.5	7.6	7.5	7.6	7.5	7.4	7.5
	7.5	7.4	7.6	7.5	7.5	7.6	7.6	7.5
Average	7.5	7.5	7.6	7.5	7.5	7.6	7.5	7.5
Juiciness[4]	7.0	7.1	7.3	7.1	7.1	7.1	6.9	7.1
	7.1	7.1	7.4	7.3	7.0	7.1	7.3	7.2
Average	7.0	7.1	7.3	7.2	7.1	7.1	7.1	7.1
Acceptability[4]	7.3	7.3	7.5	7.3	7.0	7.3	6.9	7.2
	7.3	7.3	7.4	7.4	7.2	7.4	7.3	7.3
Average	7.3	7.3	7.5	7.4	7.1	7.3	7.1	7.3

[1]H=Hereford; A=Angus; J=Jersey; SD=South Devon; L=Limousin; C=Charolais; S=Simmental. Breed of sire is first and breed of dam is second.

[2]Prime = 15, 14, 13; Choice = 12, 11, 10; Good = 9, 8, 7; Standard = 6, 5, 4.

[3]Abundant = 27, 26, 25; Moderately abundant = 24, 23, 22; Slightly abundant = 21, 20, 19; Moderate = 18, 17, 16; Modest = 15, 14, 13; Small = 12, 11, 10; Slight = 9, 8, 7; Traces = 6, 5, 4; Practically devoid = 3, 2, 1.

[4]Extremely desirable = 9; Desirable = 8; Moderately desirable = 7; Slightly desirable = 6; Acceptable = 5; Slightly undesirable = 4; Moderately undesirable = 3; Undesirable = 2; Extremely undesirable = 1.

Table 12.—*Percentage of carcasses by grades within breed groups*

		Breed groups[1]							
Grade		HH	AA	HAX	JX	SDX	LX	CX	SX
Prime	High								
	Avg		2.4	0.5	0.7			1.1	
	Low		8.2	1.4	.7			3.4	0.6
Choice	High	4.3	15.3	8.6	11.2	9.6	0.6	2.3	3.4
	Avg	10.2	32.9	21.9	26.1	24.5	9.2	16.9	16.1
	Low	33.3	23.5	37.1	28.4	35.1	18.4	35.6	31.0
Good	High	27.5	7.1	16.2	22.4	13.8	27.6	16.9	17.2
	Avg	13.0	7.1	9.0	6.7	9.6	25.9	13.6	16.7
	Low	10.2	3.5	4.3	3.7	7.4	14.9	7.9	12.6
Standard	High	1.4		1.0			2.9	.6	1.7
	Avg						.6	1.1	.6
	Low							.6	

[1]=Hereford, A=Angus, J=Jersey, SD=South Devon, L=Limousin, C=Charolais, S=Simmental, X=Crossbred.

Conclusions

1. Significant differences were shown among breed group means in growth rate of retail product, fat trim, bone, ribeye fat percentage, quality grade, and in taste panel tenderness.
2. When compared at age, weight, or ribeye fat constant endpoints, the differences among breed groups in composition of retail product, fat trim, and bone were greatest at a constant carcass weight and smallest at equal fat in the ribeye.
3. Breed groups with higher growth rates tended to have higher percentages of retail product and bone and lower percentages of fat trim.
4. Retail product percentage declined and fat trim percentage increased in all breed groups as time on feed advanced.

5. Breed groups with higher growth rates tended to have less fat in the ribeye muscle and reached Choice grade at signicantly different weights.

6. Average taste panel scores for all breed groups were well above the minimum levels of acceptability; differences were small.

7. Breed crosses with higher marbling scores had slightly higher tenderness scores, and within breed and slaughter groups tenderness per unit of marbling increased slightly.

8. Marbling increases caused by time on feed did not result in an increase in taste panel tenderness or acceptability.

GROWTH AND PUBERTY OF HEIFERS[11]

D. B. Laster[12]

Puberty traits in beef cattle are important criteria for evaluating breed use in different beef production systems. Although puberty has been studied in several domestic breeds, little information is available on puberty and pregnancy in domestic and Western European breeds evaluated under similar management conditions.

This study involved evaluation of growth and puberty of the 945 female calves produced in Cycle I of the cattle germ plasm evaluation program at the U.S. Meat Animal Research Center.

Experimental Procedure

Following weaning, heifers were randomized by breed group to five feedlot pens (all breed groups represented in each pen) and fed a ration, free choice, consisting of approximately 50 percent corn silage and 50 percent grass haylage with adequate supplemental protein and minerals to meet National Research Council requirements. Heifers were bred by artificial insemination (AI) for 42 to 45 days followed by 21 to 25 days of natural matings. Average age was 430 days at the beginning of AI breeding. Estrus was checked visually twice daily from an average age of 250 days to the end of the natural breeding period, except estrus was determined only to the end of the AI breeding period in calves born in 1970. Heifers that calved were classified as pregnant; those that did not calve were classified as nonpregnant. Body weights were taken at 28-day intervals: from weaning to beginning of AI breeding, end of AI breeding, and approximately 550 days of age.

Puberty age was defined as the age first observed standing estrus. Puberty weight was calculated by adding weaning weight to postweaning average daily gain (ADG) times days from weaning to puberty. Adjusted values were determined for age and weight at puberty for each breed group because estrus was not observed in all animals. Observed values were biased downward. This adjustment removed the bias in the overall mean and allowed unbiased comparisons of breed groups differing in percentage observed in estrus.

Weight-age curves were determined by quadratic regression of breed group means for each 28-day weight on days fed separately for each breed group and year. Corrected sums of squares and products were pooled over the 3 years to obtain breed group regressions. The percentage reaching puberty by various ages was plotted against weights from the weight-age curves to obtain percent puberty-weight curves for each breed group, thus, evaluating puberty age associated with related changes in live weight.

Results

Growth

Breed group comparisons for birth weight and preweaning growth (table 13) represent data only from heifers on which puberty data were obtained. Actual weaning weights of heifers from the different breed crosses rank the same as the adjusted 200-day weights for calves of both sexes, except for the Limousin crosses, which were 6 days younger at weaning than the overall average weaning age for the heifers.

Sire breed, years within sire breed, and sires within-year-within sire breed significantly affected all preweaning and postweaning growth traits. Actual weaning weights were similar for Charolais, Simmental, South Devon, and Hereford-Angus crosses and higher for these breed crosses than for Limousin and Jersey crosses (table 13). Jersey

[11]Results presented here were taken from D. B. Laster, Gerald M. Smith and Keith E. Gregory. Characterization of biological types of cattle. IV. Postweaning growth and puberty of heifers. J. of Anim. Sci. 43 (1976). Persons desiring a more detailed statistical evaluation are referred to this paper.

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Table 13.—*Least squares means for birth weight, pre-weaning and postweaning growth, and pregnancy*

Breed group[1]	No.	Birth weight	Actual weaning weight	ADG, Wn to 400 days	400-day weight[2]	ADG, 400-450 day weight[3]	550-day weight[4]	Pregnancy[5]
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Percent*
Hereford	62	75.0	416	0.94	576	1.06	673	78.2
Angus	64	66.2	440	1.00	605	1.19	673	82.3
HA+AH	132	71.3	447	1.07	629	1.25	715	93.0
Jersey—X	117	61.8	414	.90	561	1.20	656	86.4
S. Devon—X	120	77.2	447	1.17	651	1.35	741	85.1
Limousin—X	161	76.3	436	1.10	640	1.03	713	82.0
Charolais—X	132	81.6	469	1.15	671	1.26	757	80.6
Simmental—X	157	80.5	464	1.15	671	1.21	768	86.2
Hereford dams	504	76.8	431	1.08	625	1.13	717	84.0
Angus dams	441	71.7	455	1.07	636	1.28	717	85.6

[1]H=Hereford; A=Angus; Jersey-X=Jersey sires by Hereford and Angus dams, and so forth.

[2]Birth wt + (200 × prewn. ADG) + 200 × ADG from weaning to approximately 400 days of age.

[3]Gain during the artificial insemination breeding period.

[4]Actual weight taken at approximately 550 days of age.

[5]The breeding period was 42 to 45 days by artificial insemination followed by 21 to 25 days by natural mating.

crosses gained less from weaning to 400 days of age (fig. 10). At 400 days Charolais, Simmental, and South Devon crosses were heaviest, Hereford-Angus and Limousin crosses were intermediate and Jersey crosses were lightest (table 13 and fig. 10). Weights at 400 days of age were similar for straightbred Hereford and Jersey crosses, and straightbred Angus were similar to Limousin and Hereford-Angus crosses.

Dam age significantly affected all growth traits except ADG from 400 to 450 days of age (AI breeding period). Preweaning growth and weight at 400 days increased as cow age increased. ADG from weaning to 400 days decreased as dam age increased, indicating compensatory postweaning gain for heifer calves from young cows.

All growth traits, except ADG from weaning to 400 days of age, were significantly influenced by dam breed. Calves from Angus dams were 22 lbs heavier at weaning and 20 lbs heavier at 400 days of age than those from Hereford dams. Weaning weights of Jersey sired calves from Angus dams were only 6.6 lbs heavier than those from Hereford dams, while calves sired by South Devon, Limousin, Charolais, and Simmental calves from Angus dams were from 20 to 37 lbs heavier than calves from Hereford dams.

Breed-of-sire by breed-of-dam interaction for weaning weight indicates that calves with a higher genetic growth potential responded more to the presumably higher milk production levels of the Angus dam during preweaning growth. The 400-day weights of heifers sired by Limousin and Charolais sires were 26 lbs heavier from Angus dams than those from Hereford dams, but heifers from Angus and Hereford dams by the other sire breeds ranged from 6.6 lbs heavier from Angus dams to 6.6 lbs heavier from Hereford dams. The physiological basis for this interaction is not obvious. Rank and relative differences of breed groups for postweaning growth of the heifers were similar to their steer mates.

Percentage reaching puberty

Sire breed.—Percentage of heifers reaching puberty by 270 to 510 days of age (fig. 11) was significantly influenced by sire breed. For percentage reaching puberty from 300 to 450 days of age, breed crosses basically divided into three groups. A higher percentage of Jersey-cross heifers and a lower percentage of Limousin and Charolais crosses reached puberty within this age range with South Devon, Hereford-Angus, and Simmental crosses intermediate.

Individual sires within breed influenced percentage of heifers reaching puberty from 270 to 390 days of age, indicating that physiological maturity is influenced by genetic variation within a breed. Therefore, percentage of heifers reaching puberty at an early age and average puberty age could be affected by selection within a breed. A greater difference in percentage of heifers reached puberty by 510 days of age out of Angus than Hereford dams when sired by Charolais and Limousin than when sired by the earlier maturing breeds.

Dam breed.—Breed of dam averaged over all sire breeds had a large effect on percentage of heifers

reaching puberty from 270 to 510 days of age in favor of Angus dams. Breed of dam differences in percentage reaching puberty at different days of age were as follows (the values shown indicate Angus minus Hereford dam differences): 270, 2 percent; 300, 10 percent; 330, 15 percent; 360, 18 percent; 390, 16 percent; 420, 13 percent; 450, 9 percent; 480, 7 percent; and 510, 5 percent. These differences were larger than the differences between reciprocal cross Hereford-Angus and Angus-Hereford breed groups (270, 2.4 percent; 300, 6.3 percent; 330, −.5 percent; 360, 8 percent; 390, 10 percent; 420, —2 percent; 450, −3 percent; 480, 0 percent; 510, 0 percent) indicating that at least part of the difference was from transmitted effects of the Angus breed as well as any maternal (milk) effect of the dam.

Dam age.—Effects of dam age on percentage reaching puberty by 390 days of age related to dam age on weaning weight. Fewer heifers from 2-year-old dams had reached puberty by 390 days of age, and the percentage increased as dam age increased from 2 to 5 years and older. The mean percentage reaching puberty for all breed groups at 390 days was 62 percent, and the percentages for each of the four age-of-dam classifications were 51 percent, 61 percent, 65 percent, and 71 percent for cows 2, 3, 4, or 5 years and older.

Heterosis.—Heterosis effects were large for percentage reaching puberty between 300 and 510

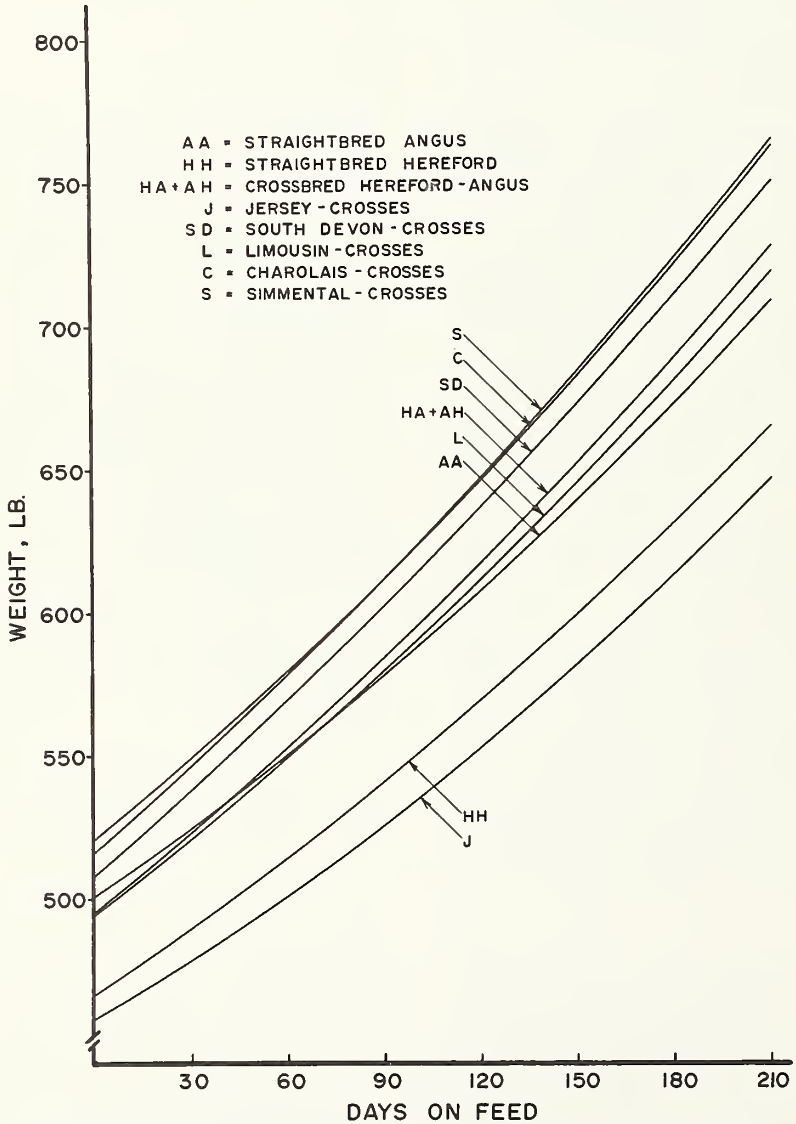

Figure 10.—Body weights of the breed groups during the post-weaning period.

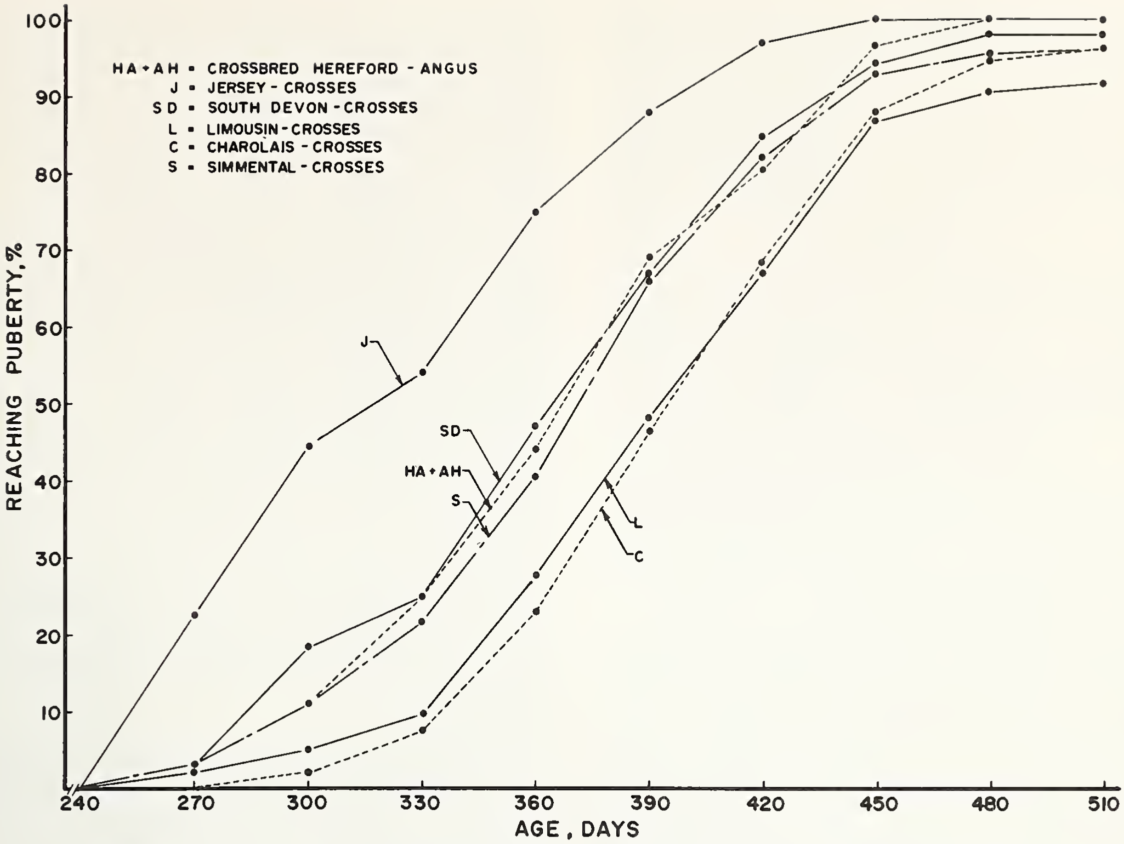

Figure 11.—Percentage of heifers in each breed cross reaching puberty at 240 to 510 day of age.

days of age. By 510 days 100 percent of the Hereford-Angus crosses had reached puberty compared to 92 percent of the Hereford and Angus straightbreds. Heterosis effects on percentage reaching puberty at the different days of age were 300, 9 percent; 330, 11 percent; 360, 13 percent; 390, 20 percent; 420, 6 percent; 450, 14 percent; 480, 12 percent; and 510, 8 percent.

Age and weight at puberty

Sire breed.—Age and weight at puberty were significantly affected by sire breed, sires within breed, dam breed, and dam age. Jersey crosses were youngest at puberty; Limousin and Charolais crosses oldest; and Hereford-Angus, South Devon, and Simmental crosses intermediate. Thus, breed crosses rank the same at puberty age as the percentage reaching puberty by 300 to 450 days of age (fig. 11 and table 14). The ranking of the breed crosses for percentage reaching puberty by 300 to 450 days of age and at puberty age is similar to the ranking of the final maturity scores (based primarily on visual evidence for ossification of bone cartilage) of the steer carcasses from the male mates to these heifers. The strong association between these two independent measures of physiological maturity indicates that a difference exists in rate of physiological maturity among the different breed crosses.

Jersey crosses were lightest at puberty weight, followed by Hereford-Angus and South Devon crosses; next were Limousin and Simmental crosses. Charolais crosses were heaviest (table 14). Ranking of the breed crosses at puberty weight is similar to the ranking for birth weight and 400-day weight, except puberty weight for Limousin crosses was heavier relative to their birth weight and 400-day weight than the other breed crosses (tables 13 and 14). Ranking seems to further indicate that Limousin crosses reach a similar stage of physiological maturity at a later age and weight relative to their growth rate and that Charolais crosses reach this stage of physiological maturity at a later age than other breed crosses represented in this study.

As dam age increased there was a tendency for puberty age to decrease more in Jersey crosses, and in Hereford- and Angus-sired breed groups, than other breed crosses. Therefore, breed crosses with a

Table 14.—*Age and weight at puberty by breed group*

Breed group	No.	Age at puberty	Weight at puberty
		Days	*Pounds*
Hereford	62	415	603
Angus	64	366	561
Heterosis		—19.5	3
HA+AH	132	371	585
Jersey—X	117	322	482
S. Devon—X	120	364	603
Limousin—X	161	398	642
Charolais—X	132	398	667
Simmental—X	157	372	629
Hereford dams	504	389	612
Angus dams	441	363	592

greater genetic capability to reach puberty at a younger age had more opportunity for expression of this puberty trait with increased levels of milk during the preweaning period.

Figure 12 shows the percentage of animals in a given breed cross that reached puberty at different average weights. A comparison of average weights at puberty of different breed crosses in table 14 to the data in figure 12 reveals that less than 50 percent of the heifers of any breed cross reached puberty when the average weight for that breed cross was equal to the average puberty weight given in table 14. However, interesting to note are the means for age at puberty (table 14) that correspond closely to median age at puberty (age at which 50 percent reached puberty). These data indicate the importance of determining percentage of heifers reaching puberty at different ages; in addition the data show the average age and weight at puberty for evaluating breed and treatment effects on puberty traits and for developing feeding programs to optimize reproductive performance of a given breed group.

Dam breed and age.—Heifers from Angus dams reached puberty 26 days earlier and were 19.8 lbs lighter than those from Hereford dams (table 14). Dam age affected puberty age and weight with heifers from younger dams reaching puberty at an older age and at a lighter weight. Puberty ages of heifers for different ages of dam were 387, 368, 353, and 357 days; puberty weights were 568, 587, 592, and 607 lbs for 2-, 3-, 4-, $\geq$5-year-old dams, respectively.

Heterosis.—In the present study, puberty age was 19.5 days earlier in the Hereford-Angus crosses than the average for the straightbreds (table 14). Heterosis had little effect on weight at puberty (table 14).

Pregnancy

Sire breed of the heifers did not affect pregnancy percentage. Pregnancy percentages were higher for Limousin, Charolais, and Simmental crosses from Angus dams than from Hereford dams. In Jersey and South Devon crosses, pregnancy percentages were in favor of Hereford dams. The higher pregnancy percentages suggest differential heterosis ef-

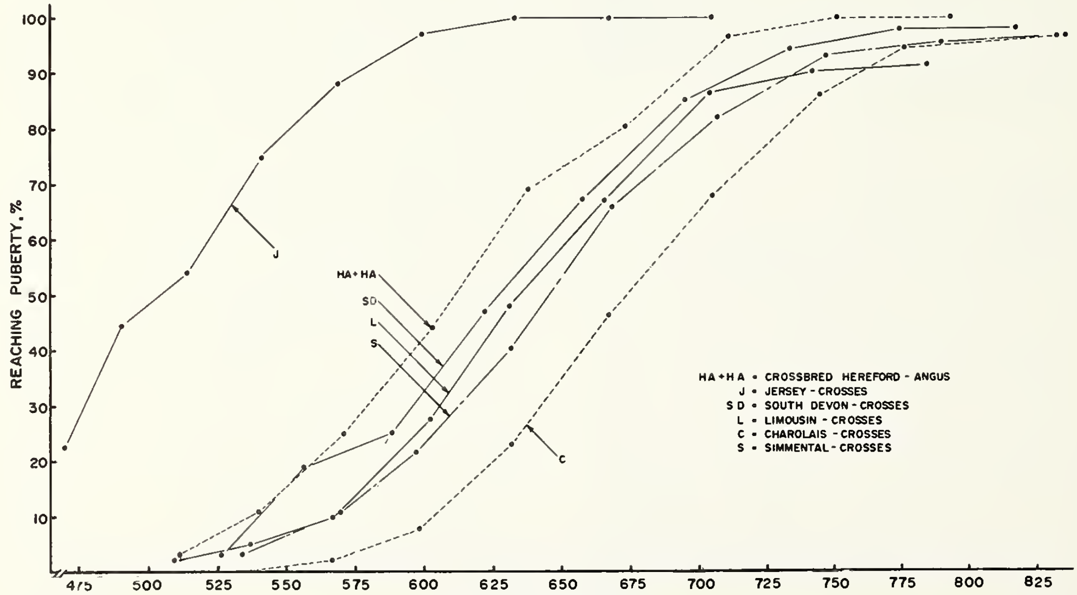

Figure 12.—Percentage of heifers reaching puberty at the average weights for the breed cross.

fects for Hereford and Angus dams when crossed with Jersey and South Devon than when crossed with Limousin, Charolais, and Simmental breeds. Also heifers sired by the larger sire breeds had a higher growth potential, which enabled them to utilize the higher milk production of the Angus dams without excess fattening.

Pregnancy percentage increased in heifers from Hereford dams as dam age increased from 2 to 4 years of age but was higher in heifers from 2-, and 3-year-old Angus dams than in those from Angus dams 4 and ≥5 years of age. Pregnancy percentages were 76, 82, 90, and 88 for heifers from 2-, 3-, 4-, and ≥5-year-old Hereford dams and 89, 90, 81, and 82 for 2-, 3-, 4-, and ≥5-year-old Angus dams. However, the pregnancy percentages were similar for heifers from Hereford dams 4 and 5 years or older to those from 2- and 3-year-old Angus dams. One possible explanation is that under the conditions of this study, higher levels of milk production in Hereford dams associated with increased age increase reproductive performance; a milk production level above that produced by 3-year-old Angus dams tended to decrease pregnancy percentage in their progeny when bred as yearlings.

Part of the reason for the lower pregnancy percentage for heifers from 2- and 3-year-old Hereford dams may have been the lower percentage of heifers from these ages of dam reaching puberty; however, this was not the reason for the lower pregnancy percentage in heifers from older Angus dams. Percentage of heifers reaching puberty by 510 days of age were 90, 92, 98, and 95 from 2-, 3-, 4-, and ≥5-year-old Hereford dams and 100, 100, 94, and 99 for heifers from comparable ages of Angus dams. Preweaning ADG for heifers from 2-, 3-, 4-, and ≥5-year-old Hereford dams were 1.43, 1.63, 1.76, and 1.83 lbs and 1.54, 1.74, 1.83, and 1.94 lbs for heifers from 2-, 3-, 4-, and ≥5-year-old Angus dams. Results indicate that preweaning maternal performance affects subsequent reproductive performance of offspring and show an optimum preweaning growth rate for optimum breeding performance of yearlings.

Conclusions

1. Charolais, Simmental, and South Devon crosses were the heaviest at 400 days of age followed closely by Hereford-Angus and Limousin crosses; Jersey crosses were lightest—16 percent lighter than Charolais and 8.7 percent lighter than Limousin crosses at 400 days.
2. Breed crosses separated into three distinct groups for percentage of heifers reaching puberty at each 30 days from 300 to 450 days of age. A higher percentage of Jersey crosses and a lower percentage of Charolais and Limousin crosses reached puberty with Hereford-Angus, South Devon, and Simmental crosses intermediate throughout this age range.
3. Breed crosses divided into the same three groups on the basis of average age at puberty: Charolais crosses were heaviest, followed by Limousin and Simmental, then South Devon and Hereford-Angus, with Jersey crosses the lightest.
4. Charolais and Limousin crosses reach a similar stage of physiological maturity at an older age and Jersey crosses at a younger age than other breed crosses.
5. Heifers from Angus dams were 26 days younger and 19.8 lbs lighter at puberty than those from Hereford dams.
6. Heterosis in Hereford-Angus reciprocal crosses for age at puberty was 19.5 days with no effect on weight at puberty.

ESTIMATING RETAIL PRODUCT[13]

John D. Crouse[14]

Retail product yield is a useful measure for the saleable portion of carcass beef. Time and resources are often not available to obtain actual retail yields, thus, reliable estimates are needed in marketing, progeny testing, and research programs.

Numerous equations for estimating percentage of carcass cutability have been developed on carcasses derived from British beef, dairy, and Brahman breeding. The present USDA (1965) yield grade equation estimates percentage of closely trimmed, boneless round, loin, rib, and chuck. In this regres-

[13]Results presented here were taken from (1) J.D. Crouse, M. E. Dikeman, R. M. Koch, and C. E. Murphey. Evaluation of traits in the USDA yield grade equation for predicting beef carcass cutability in breed groups differing in growth and fattening characteristics. J. Anim. Sci. 41, 548 (1976) and (2) J. D. Crouse, and M. E. Dikeman. Determinates of retail product of carcass beef. J. Anim. Sci. 42, (1976). Persons desiring a more detailed statistical evaluation are referred to these papers.

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sion equation, independent variables are those that can be measured rapidly with minimal expense on carcasses in the cooler. The equation was tested on independent populations of carcass beef and found useful on carcasses from animals having the same growth and fattening patterns.

This section develops prediction equations to estimate retail product for carcass beef from 1121 steers produced in Cycle I. Variables used as predictors reflect different situations relative to resources available for required observations.

Experimental Procedure

Yield and quality grade were determined 24 hr postmortem by a consensus of three appraisers. Ribeye area (REA) at the 12th rib was traced, and the area was determined by planimeter. Fat thickness (FT) over the 12th rib was measured according to procedures described in the USDA (1965) grading standards for carcass beef and was adjusted for abnormal fat deposition over the carcass. Muscling was scored from 1 (extremely thick) to 10 extremely thin).

Carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone, hindquarter length from the anterior edge of the 13th thoracic vertebra to the anterior edge of the aitch bone, and round length from the anterior edge of the aitch bone to the line of the epiphyseal plate at the distal end of the tibia. Round thickness was measured with calipers at the thickest point above the symphysis pubis (as the carcass hangs) but below the round collar fat. Chuck thickness was measured at the thickest distance over the clod with the split surface of the fifth vertebra used as a reference point. Chest depth was measured by anchoring one arm of the calipers in the ventral side of the spinal canal at the midpoint of the fifth thoracic vertebra and measuring to the midpoint of the ventral edge of the fifth sternebra.

The right side of each carcass was taken to Kansas State University and processed into trimmed retail cuts with no more than .3 in fat cover. Minor cuts were made entirely boneless, trimmed to 25 percent fat, and included in lean trim. Dorsal and transverse spinous processes remained in the short loin cuts, and dorsal spinous processes and rib bones remained in the rib cuts. All other cuts were made entirely boneless. Kidney and pelvic (K and P) fat of the right side was weighed and expressed as a percentage of the right side weight.

Percentage of retail product was determined by the weight of the trimmed retail yield from the round, loin, rib, and chuck, plus lean trim from the entire side, and divided by the sum of individual weights of all components of the side. Ether extract was determined on lean trim. Retail yield was arithmetically adjusted to 25 percent fat in the lean trim, considering physically separated fat to be 85 percent ether extractable, to reduce fabrication errors. Percentages of rib retail product, rib fat trim, round retail product, and round fat trim were expressed relative to weights of their respective wholesale cuts. From 334 carcasses of the 1971 calf crop, the left 9-10-11th rib section was removed 24 hr after slaughter, boned, and soft tissue analyzed for ether extract and moisture.

Data were analyzed by correlation and multiple regression techniques to develop equations for predicting percentage of retail product. Cooler, rib chemical, and partial cutout data were analyzed as three independent data sets and subsequently pooled and analyzed as one data set to develop appropriate equations for different resources situaions. Subclass mean effects for breeds of dam and years were removed by pooling within respective classes.

Results

Means and standard deviations of traits studied are given in table 15. Standard deviations were computed over all sire breeds or pooled within sire breeds. The pooled standard deviations estimate residual variation after removal of effects of sire breed group means. In this study, variation over all sire breeds is larger than would be expected from carcasses within a given breed fed for a constant time.

The carcass population studied had an average hot carcass weight of 646 lb; approximately 9 percent of the overall variation was accounted for by sire breeds. The carcasses averaged 68 percent retail product. Estimates of K and P fat percentage were .9 percent less than actual values. Mean values for actual and adjusted fat thickness were the same; however, adjustments of actual FT reduced the variation of one standard deviation from .20 to .18 in. This reduction in variation would be expected for the adjusted FT values because most of the variation in carcass dressing has been removed.

Correlations between carcass traits and percentage of retail product are given in table 16. Correlations were calculated over all sire breeds or were

Table 15.—*Means and standard deviations of carcass traits of 1,121 steers obtained from seven breeds of sire*

Traits	Mean	SD[1]	SD[2]
Carcass length ______________inches__	47.5	1.9	1.8
Hindquarter length ___________do____	48.5	2.0	1.7
Round length _______________do____	24.6	1.1	.9
Chuck thickness _____________do____	8.1	.5	.5
Round thickness _____________do____	10.1	.6	.5
Depth of chuck ______________do____	14.4	.7	.6
Ribeye area ____________square inch__	11.7	1.5	1.2
Overall conformation[3] _______________	11.49	1.33	.98
Muscling conformation[3] ______________	11.07	1.42	1.02
Muscling score[4] ____________________	3.64	1.17	.85
Marbling score[5] ____________________	11.53	3.42	3.11
Hot carcass weight __________pound__	646	78	71
Fat thickness _________________inch__	.50	.20	.18
Adjusted fat thickness ________do____	.50	.18	.15
Estimated K and P fat _______percent__	3.102	.940	.725
Actual K and P fat ___________do____	3.977	1.065	.815
Yield grade ________________________	2.958	.765	.647
Longissimus muscle fat _______percent__	5.39	2.16	1.93
Rib moisture[6] (9-10-11th rib) ____do____	43.91	4.51	3.64
Rib fat[6] (9-10-11th rib) ________do____	43.0	5.8	4.7
Rib protein[6] (9-10-11th rib) ____do____	12.07	1.85	1.67
Rib retail product ___________percent__	75.82	4.28	3.57
Rib fat trim _________________do____	16.16	4.65	3.90
Trimmed round _______________do____	22.72	1.54	1.15
Round retail product __________do____	75.52	2.26	1.88
Round fat trim _______________do____	7.79	2.55	2.09
Retail product (side) __________do____	67.95	4.50	3.59

[1]Standard deviations were computed over all breeds of sire and pooled within breeds of dam and years.

[2]Standard deviations were computed and pooled within breeds of sire, breeds of dam, and years.

[3]Coded: choice$^-$ = 10, choice$^\circ$ = 11, choice$^+$ = 12, and so forth.

[4]Scored 1 = extremely thick to 10 = extremely thin.

[5]Coded: small$^-$ = 10, small$^\circ$ = 11, small$^+$ = 12, and so forth.

[6]Data obtained on 334 carcasses for the 1971 calf crop.

pooled within sire breeds. Results from the overall analysis would be appropriate when inference is drawn to a population of carcasses derived from a number of breeds or breed crosses that differ significantly in growth rate and body composition. Results from the pooled within breed group analysis approximate the average correlation between traits for the seven sire breed groups. The pooled within breed group correlations would more accurately reflect biological relations among carcasses from a given breed group because the effects of breed group means have been removed.

A correlation of —.18 was observed between hot carcass weight and percentage of retail product on an overall breed group basis. However, on a within breed group basis this correlation increased in magnitude to —.46. The effects of breed group means on the relation of carcass weight and retail product percentage were discussed previously and are depicted in figure 7. The heavier carcasses associated with later maturing breed types often had the highest cutability, while within-breed types the heavier carcasses had lower cutability.

Of the cooler measurements, FT was the best single estimator of retail product. FT is also highly associated with other body composition traits. The correlation between percentage of retail product and FT, like other estimates of fat depots such as K and P fat, was not appreciably affected by variation associated with sire breeds. The correlation of —.38 within breed groups indicates that marbling score may be useful as an additional predictor of retail product. In general, measurements of fat deposition are the best predictors of body composition caused by the relative variability of body fat as compared with lean or bone.

Table 16.—*Correlations between carcass traits and retail product*[1]

Carcass trait	Percentage retail product	
	Overall[2]	Within[3]
Carcass length _____________________	—.11	—.32
Hindquarter length _________________	—.04	—.30
Round length ______________________	.09	—.21
Chuck thickness ____________________	—.18	—.38
Round thickness ____________________	.17	—.16
Chuck depth _______________________	—.11	—.21
Ribeye area ________________________	.41	.15
Overall conformation ________________	.27	.06
Muscling conformation _______________	.51	.30
Muscling score _____________________	—.58	—.38
Marbling score _____________________	—.48	—.38
Hot carcass weight __________________	—.18	—.46
Fat thickness ______________________	—.68	—.64
Adjusted fat thickness _______________	—.79	—.77
Estimated K and P fat ______percent__	—.39	—.38
Actual K and P fat ___________do____	—.42	—.47
Longissimus muscle fat ________do____	—.61	—.51
Rib fat[4] (9-10-11th rib) ________do____	—.90	—.84
Rib moisture[4] (9-10-11th rib) ____do____	.88	.79
Rib protein[4] (9-10-11th rib) ____do____	.71	.62
Rib retail product _____________do____	.79	.74
Rib fat trim __________________do____	—.81	—.77
Trimmed round ________________do____	.83	.76
Round retail product ___________do____	.78	.72
Round fat trim ________________do____	—.79	—.76

[1]Correlations $\geq$.06, P$<$.05; correlations $\geq$.08, P$<$.01.

[2]Correlations were calculated over all breeds of sire.

[3]Correlations were based on a pooled within breeds of sire SS and CP matrix.

[4]Correlations were based on 334 observations.

Estimates of muscling (REA, muscling score, and muscling conformation) had potential as predictors of retail product as indicated by their correlations with percentage of retail product from .15 to —.38 on a within breed of sire basis.

Ribeye area was relatively more important as a predictor of retail product at constant carcass weights than when carcass weight varied because REA and carcass weight were positively correlated within breed groups but opposite in their correlation with percentage retail product. Consequently, REA is a more useful predictor of retail product in carcasses of similar weight than in carcasses of varying weight.

Carcass, hindquarter, and round length; chuck and round thickness, and chuck depth were more closely correlated with percentage of retail product within sire breed subclasses than overall sire breeds. Negative within subclass correlations for linear carcass measurements indicated that shorter, thinner carcasses yielded high percentages of retail product. However, on an overall breed basis, the carcasses with longer, thicker rounds yielded the high percentages of retail product.

Percentage chemical fat of soft rib tissue was the single trait most highly associated with percentage of retail product ($r = -.90$ over all breed groups and $r = -.84$ within breed groups) of all traits measured. The magnitude of the correlations in the present study and in previous findings suggests that rib composition would be a valuable predictor of carcass retail product.

Regression equation results with standard errors and coefficients of determination (R^2) for predicting percentage of retail product are given in table 17. Coefficients of determination times 100 ($R^2 \times 100$) give the relative amount of variation accounted for by the regression equation: the greater the R^2, the greater the accuracy of an equation. Standard errors (SE) reflect the reliability of an equation or precision: the smaller the SE, the greater the precision. Equations are presented on both an overall and a pooled within breed of sire subclass basis. Inferences from the overall analysis are applicable to a population of carcasses similar to those of the breed groups sampled. Results from the pooled within breed group analyses represent the average response for the seven sire breed groups. Independent variables presented are those that were identified as the most important by stepwise regression procedures and of practical use in various resource situations. Additional, independent variables were statistically significant and made some improvement in the equations, but these contributions were negligible and of little practical consequence.

Results of equations (table 17) 1 through 4 (overall subclasses) and equations 9 through 12 (within subclasses) involve independent variables observed in the cooler, which can be obtained rapidly and with modest expense. Equations 1, 3, 9, and 11 omit hot carcass weight. Using hot carcass weight in an equation representing all breed groups is somewhat questionable.

Equation 1, without hot carcass weight, accounted for 75.4 percent ($R^2 \times 100$) of the variation in percentage retail product. Equation 2, with hot carcass weight present, accounted for 76.5 percent of the variation in percentage retail product. Multiple regression equations utilizing hot carcass weight as a predictor overestimated the Hereford and Angus, Jersey, and South Devon groups and underestimated the Charolais, Simmental, and Limousin group more than when hot carcass weight was omitted from the equation.

Cooler measurements of length and thickness of the carcass or carcass components made no practical contribution to the predictive value after marbling score entered the equations. Subjective measurements of carcass muscling were important as predictors of retail product. However, once marbling score entered the equation, the contribution of muscling score was minimal.

Preliminary correlation analysis of all closely trimmed wholesale cuts with percentage of retail product indicated that the wholesale round and the rib cuts were good indicators of closely trimmed carcass retail product. Consequently, regression equations were generated utilizing independent variables derived from cooler observations and partial cutout of the round and rib. Equations 5 and 13, involving percentage of trimmed round and percentage of retail product of the round, incorporated adjusted FT and the actual percentage of K and P fat. Variation in actual K and P fat was more highly associated with variation in retail product than estimated K and P fat as shown by the results of the correlation analysis (table 16). Actual percentage of K and P fat could be determined if the round was processed; subjectivity would be removed from estimating. Equations 5 and 13 accounted for 86.1 and 79.1 percent of the variation in percentage of retail product, respectively.

Equations 6 and 14 (involving adjusted FT, estimated percentage of K and P fat, marbling score,

Table 17.—*Regression equations for predicting percentage of retail product*

Subclass basis, and equation number	N	SE	R^2	Intercept	Partial regression coefficients: Adjusted FT	Ribeye area	Estimated K and P fat	Carcass weight	Marbling score[1]	Actual K and P fat	Trimmed round	Round RP[2]	Rib fat trim	Rib chemical fat
					Inches	*Square inch*	*Percent*	*Pounds*		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Overall:[3] 1	1121	2.23	.754	74.9	—17.77	.55	—1.47	----	----	----	----	----	----	----
2	1121	2.18	.765	75.6	—16.08	.86	—1.42	—.0084	----	----	----	----	----	----
3	1121	2.11	.780	73.6	—16.50	.56	—1.23	----	—.234	----	----	----	----	----
4	1121	2.05	.792	77.0	—14.66	.89	—1.17	—.0090	—.240	----	----	----	----	----
5	1121	1.68	.861	1.9	— 8.16	----	----	----	----	—.78	.89	.70	----	----
6	1121	2.00	.802	85.1	— 9.28	----	—1.15	----	—.219	----	----	----	—.403	----
7	334	1.70	.855	87.0	— 8.01	.33	— .70	----	----	----	----	----	----	—.399
8	334	1.44	.895	37.4	— 5.66	----	----	----	----	—.911	----	.65	----	—.296
Within:[4] 9	1121	2.08	.655	75.8	—17.14	.37	—1.18	----	----	----	----	----	----	----
10	1121	2.02	.673	77.2	—14.59	.67	—1.06	—.0102	----	----	----	----	----	----
11	1121	1.99	.687	76.8	—16.10	.42	—1.07	----	—.215	----	----	----	----	----
12	1121	1.92	.705	78.3	—13.54	.72	— .95	—.0103	—.215	----	----	----	----	----
13	1121	1.61	.791	34.2	—13.97	----	----	----	----	—1.20	.53	.44	----	----
14	1121	1.84	.730	83.3	— 9.38	----	— .85	----	—.186	----	----	----	—.363	----
15	334	1.65	.781	86.2	— 8.52	.34	— .68	----	----	----	----	----	----	—.377
16	334	1.40	.840	35.3	— 5.68	----	----	----	----	—.85	----	.66	----	—.269

[1]Scored small⁻ = 10, small° = 11, small⁺ = 12, and so forth.

[2]Percentage retail product of the round.

[3]Regression equations were computed over all breed of sire subclasses.

[4]Regression equations were based on a pooled within breeds of sire subclass SS and CP matrix.

and percentage of rib fat trim) were not as accurate or reliable as equations using partial cutout of the round. However, the equation did account for 80.2 percent of the variation in retail product percentage.

Chemical fat composition of the 9-10-11th rib, in addition to adjusted FT, REA, and percentage of K and P fat, was used in equations 7 and 15 and accounted for 85.5 percent of the variation in percentage of retail product over all sire breeds. Equation 7 was a significant improvement over equation 1 increasing the R^2 by 10.1 percent and reducing the SE by 23.8 percent.

Equations 8 and 16 (involving independent variables adjusted FT, actual percentage of K and P fat, percentage of round retail product, and percentage of chemical fat of the 9-10-11th rib) provided the best fit. The two equations accounted for 89.5 and 84.0 percent of the variation in percentage of retail product over all and pooled within sire breed subclasses, respectively. Standard errors of the respective equations were 1.44 and 1.40 percent. Equation 8 should provide a useful alternative to complete carcass processing for determining retail product where a small error in estimation can be tolerated.

Study results indicate that adequate alternatives exist to complete carcass processing to obtain information on retail product yield. The accuracy and reliability of these alternatives are related to the time and resources provided for labor and instrumentation required to make carcass observations. However, estimates adequate for many purposes—namely, group averages involving a large number of observations—can be made with relatively small input.

Conclusions

1. Percentage fat of the soft tissue of the 9-10-11th rib cut was the best single predictor of retail product.
2. Partial retail cutout of the round or the rib was a useful adjunct for predicting retail product.
3. Adjusted fat thickness was the single best predictor of retail product of traits observed in the cooler.
4. Ribeye area was a better predictor of retail product at constant carcass weights than when carcass weight varied greatly.
5. Carcass weight was of little value in predicting retail product when used in a multiple regression

equation and led to biased results when used on a carcass population representing many breed types.

6. Adequate alternatives exist to complete processing of carcasses in determining retail product yields with reasonable accuracy.

PREDICTIVE VALUE OF CARCASS QUALITY GRADE FACTORS FOR PALATABILITY CHARACTERISTICS[15]

Dennis R. Campion[16]

USDA (1965) beef quality grades segregate carcasses into categories (grades) that differ in eating characteristics or palatability of cooked meat. Because of promotional enterprise based on this premise, considerable differences in economic value are associated with the various grades. Therefore, ability of these grades to reflect differences in palatability is of great importance to the consumer and to the producer.

Figure 13 illustrates the relation between marbling and maturity in determing grades: marbling is a subjective score of intramuscular fat in the ribeye at the 12th rib; maturity is a subjective evaluation of physiologic age determined from the skeleton and lean meat. Increasing levels of marbling are required as carcass maturity advances. These two factors, marbling and maturity, determine quality grade. To arrive at the final quality grade, that is, USDA Prime, Choice, Good and Standard, carcass conformation must also be considered.

For carcasses of A maturity, if conformation score is lower than quality, the final grade may be lower than the quality grade (again, marbling and maturity determine quality grade; quality grade and conformation score determine the final or USDA quality grade). If conformation score is higher than quality grade, the final grade cannot exceed quality grade in USDA Prime, Choice, and Good grades. Within the Standard grade, however, superior conformation can compensate for inferior quality. Carcasses with Standard quality and superior conformation can grade no higher than low Good. In addition, final quality grade may be lowered by one-third or more when the lean tissue at the 12th rib appears excessively dark, lacking in firmness, or coarsely textured.

In this study, the USDA quality grade factors were assessed to determine their usefuless as predictors of cooked meat palatability in carcasses of A maturity and from steers that differed widely in growth characteristics and in body composition at time of slaughter.

Experimental Procedure

Data were collected on 496 steers—a subsample of all steers slaughtered from 1971 through 1973 during the course of Cycle I of the Germ Plasm Evaluation Program. Though animals within sire breed groups varied in age and time on feed, average age and time on feed were similar among sire breed groups. Steers were fed free choice a postweaning ration of corn silage and concentrate that averaged 2.8 Mcal metabolizable energy per kg feed.

The steers were slaughtered in a commercial packing plant. USDA (1965) carcass quality grade factors and final grade were determined 24 hours postmortem by representatives of the USDA Agricultural Marketing Service, Kansas State University, and the U.S. Meat Animal Research Center. Color, firmness, and texture were scored using a seven-point scale. Lower values indicated brighter color, firmer lean, and finer texture of the ribeye. Maturity was subjectively estimated to one-third of a maturity level

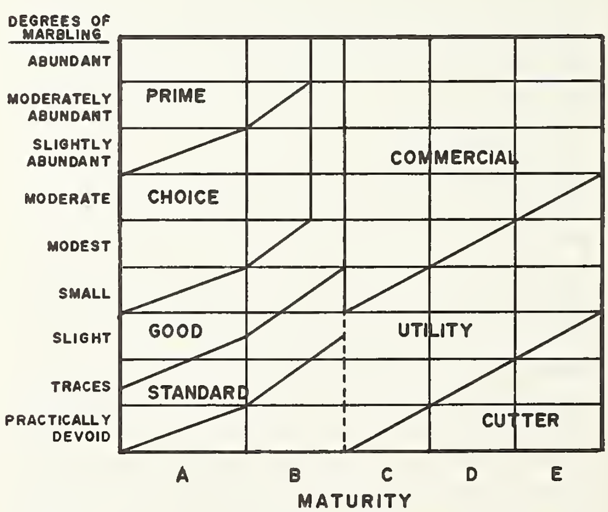

Figure 13.—Relation between marbling, maturity, and quality.

[15]Part of the results presented here were taken from D. R. Campion, J. D. Crouse and M. E. Dikeman. Predictive value of USDA beef quality grade factors for cooked meat palatability. J. Food Sci. 40, 1225 (1975).

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(1 = youngest maturity within A maturity). Conformation and final quality grades were scored to one-third of a grade (10 = low Choice, 11 = average Choice). For marbling scores, a scale ranging from 1 to 27, with increasing values indicating higher degrees of marbling (10 = small minus, 11 = average small), was used.

The right side of each carcass was transported to Kansas State University where 1.25 inch-thick steaks were removed from the wholesale rib. Intramuscular fat content was determined by ether extraction on the ribeye from the 12th rib steak after storage at −29° C. Frozen 10th and 11th rib steaks were thawed overnight at 2° to 4° C, cooked at 177° C in a preheated rotary oven to an internal temperature of 66° C, then cooled at room temperature for about 30 min before core removal and taste panel evaluation.

Six taste panel members—meat science professors and graduate students at Kansas State University—evaluated tenderness, flavor, juiciness, and overall acceptability on a 9-point scale (1 = extremely undesirable, 9 = extremely desirable) of cores taken from the 10th rib. A score of 5 indicated that the panelist judged the sample to be acceptable for the trait considered. Data were analyzed by correlation and regression procedures. Computations were derived from the pooled sums of squares and cross products within breed of dam and year to remove these average effects.

Two analyses were conducted with reference to sire breeds, overall breed groups, and within breed groups pooled overall sire breeds. Overall refers to the amount of variation accounted for across all breeds of sire, as if breed of sire were not known. Results from these analyses would be most applicable when making inference to a population of carcasses varying greatly in growth rate and fattening characteristics. In the pooled analysis, the effect of breed group means is removed and the results indicate the relative variation within breed crosses.

Results

Lean texture showed no significant relation with organoleptic traits with the exception of taste panel tenderness when analyzed on an overall basis. Lean firmness was signficantly correlated with taste panel juiciness in the overall analysis but only significantly related to taste panel flavor on the pooled-within-breed of sire evaluations. Only slight amount of variation was associated with texture and firmness mean values even though the population sampled was extremely divergent in growth characteristics. Color of lean, on the other hand, was significantly correlated with taste panel tenderness, flavor, and overall acceptability for both overall and pooled within sire breed correlations.

In the pooled analysis conformation was not correlated with any of the taste panel traits, whereas maturity showed some relation to tenderness. Marbling score was the only factor significantly related to all of the taste panel traits. No other grade factor ranked closer in relation to any of the palatability traits. For example, marbling score is more than two times more important than maturity score and 11 times as important as conformation score in accounting for variation in taste panel tenderness. But in no case did marbling account for more than 9 percent of the variation in any of the taste panel traits.

The bar graph in figure 14 depicts the amount of variation in taste panel traits accounted for by marbling, maturity, and conformation when used in a multiple regression equation. When used simultaneously, the possibility exists for these three factors to account for 0 to 100 percent of the variation in traits measured by taste panelists. If 100 percent of the variation was accounted for, marbling, maturity, and conformation, when given appropriate weight, would discern variation in palatability attributes exactly the same as the average of the panelists measured it.

Final quality grade factors accounted for a total of 9 percent of the variation in taste panel tenderness

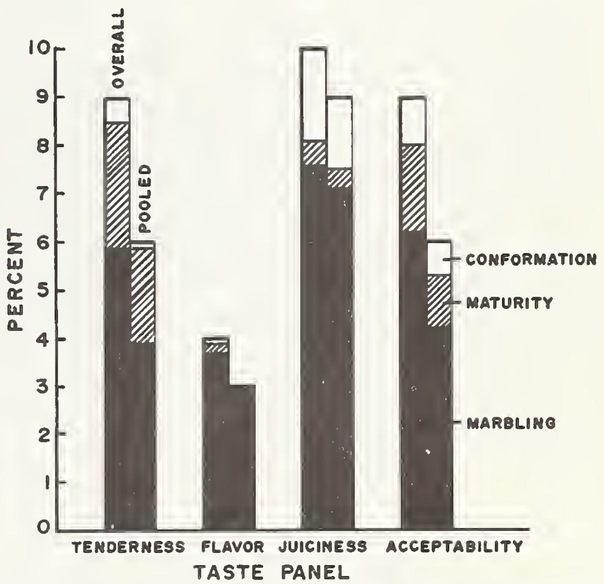

Figure 14.—Percentage of variation in taste panel traits accounted for by marbling, maturity, and conformation.

on an overall basis. Marbling score accounted for approximately 6 percent of the total variation and was clearly the most important factor in the equation. Overall, when marbling was used alone as a predictor of tenderness, it accounted for 7.8 percent. The most significant point, however, is that conformation, maturity, and marbling accounted for no more than 10 percent of the total variation in palatability traits. Consequently, their combined predictive value for eating characteristics of young carcass beef must be considered low.

Stratification of mean values for selected traits within levels of marbling (table 18) indicated that as marbling score increased from 6 (traces plus) to 17 (average moderate) there was an approximate threefold increase in percentage of ribeye chemical fat. Mean values for taste panel tenderness and acceptability differed, however, but by less than one unit over this marbling score range. Regression of taste panel tenderness on marbling score indicated that marbling score would have to change 15 units (scoring one-third of a grade on a scale of 1 to 27) within sire breeds to effect a one-unit (scale of 1 to 9) change in taste panel tenderness evaluation.

Table 18.—*Stratification of mean values within levels of marbling score*

Marbling		Num-	Ribeye	Taste panel			
Degree	Score	ber	fat	Tender-ness	Flavor	Juici-ness	Accept-ability
Abundant ----	27	2	14.8	7.7	7.3	7.5	7.3
	26	1	17.3	8.8	8.0	8.1	8.2
	25	2	12.1	8.0	8.2	8.0	8.1
Moderately abundant ---	24	1	14.6	7.7	8.3	8.2	8.1
	23	2	11.0	8.0	7.5	7.6	7.6
	22	3	12.6	7.8	8.0	8.0	7.9
Slightly abundant ------	21	3	8.8	8.0	7.4	7.3	7.5
	20	2	7.6	7.8	7.7	7.8	7.8
	19	8	8.6	7.7	7.8	7.4	7.6
Moderate -----	18	3	10.5	7.4	7.7	7.6	7.4
	17	17	8.1	7.8	7.8	7.3	7.7
	16	15	7.6	7.6	7.5	7.2	7.4
Modest -------	15	27	7.8	7.5	7.6	7.2	7.4
	14	40	7.0	7.4	7.5	7.3	7.4
	13	28	6.0	7.0	7.3	6.9	7.1
Small --------	12	46	5.5	7.4	7.5	7.0	7.3
	11	76	5.1	7.2	7.5	7.1	7.2
	10	58	4.7	7.2	7.5	7.1	7.3
Slight --------	9	65	4.3	7.3	7.5	7.2	7.3
	8	39	3.4	7.1	7.5	7.0	7.1
	7	30	2.9	6.8	7.4	6.9	6.9
Traces --------	6	14	2.9	7.3	7.4	6.9	7.2
	5	8	2.4	6.4	7.4	7.0	6.7
	4	5	2.5	6.9	7.3	6.7	7.0
Practically devoid ----	3	1	1.4	4.1	6.9	5.4	5.1

Table 19.—*Mean values for carcass composition and palatability*

Trait	Days on feed		
	184	218	251
Marbling score	Between Slight plus and Small minus	Between average Small and Small plus	Between average Modest and Modest plus
Ribeye fat -----percent--	4.5	5.3	6.4
Fat trim ------percent--	18	20	22
Retail product --percent--	69	67	66
Taste panel scores			
tenderness -----------	7.4	7.2	7.2
flavor ---------------	7.5	7.5	7.5
juiciness ------------	7.2	7.0	7.2
acceptability ---------	7.3	7.3	7.3

Mean values for taste panel traits increased slightly as final quality grade increased from Standard to Prime (fig. 15). Because a panel score of 5 meant that the rib steak was acceptable for that particular trait, the high level of tenderness and acceptability experienced by the panelists for steaks graded low Good or higher was obvious. In these data, low Good grade is equivalent to traces plus amounts of marbling and to 2.9 percent chemical fat in the ribeye. Choice rib steaks, however, rated statistically higher in overall acceptability when compared to Good grade steaks. But the practical significance is nominal as the mean acceptability score for Good grade rib steaks differed by less than 0.4 units from Choice grade steaks.

In this study, increased time on feed was associated with increased marbling score, percentage of chemical fat in the ribeye, and percentage of fat trim while percentage of retail product decreased (table 19). The additional time on feed proved costly because percentage of retail product decreased from 69 to 66 percent and percentage of fat increased from 18 to 22 percent in going from an average of 184 to 251 days on feed. Equally important, increased time on feed did not significantly change taste panel scores.

Federal grade specifications indicate that the purpose of including conformation in final grade determination is to give some assessment of yield rather than palatability. However, because the USDA quality grades of carcass beef are "merchandized" on the basis of palatability, conformation must be considered, unfortunately, as a palatability indicating trait.

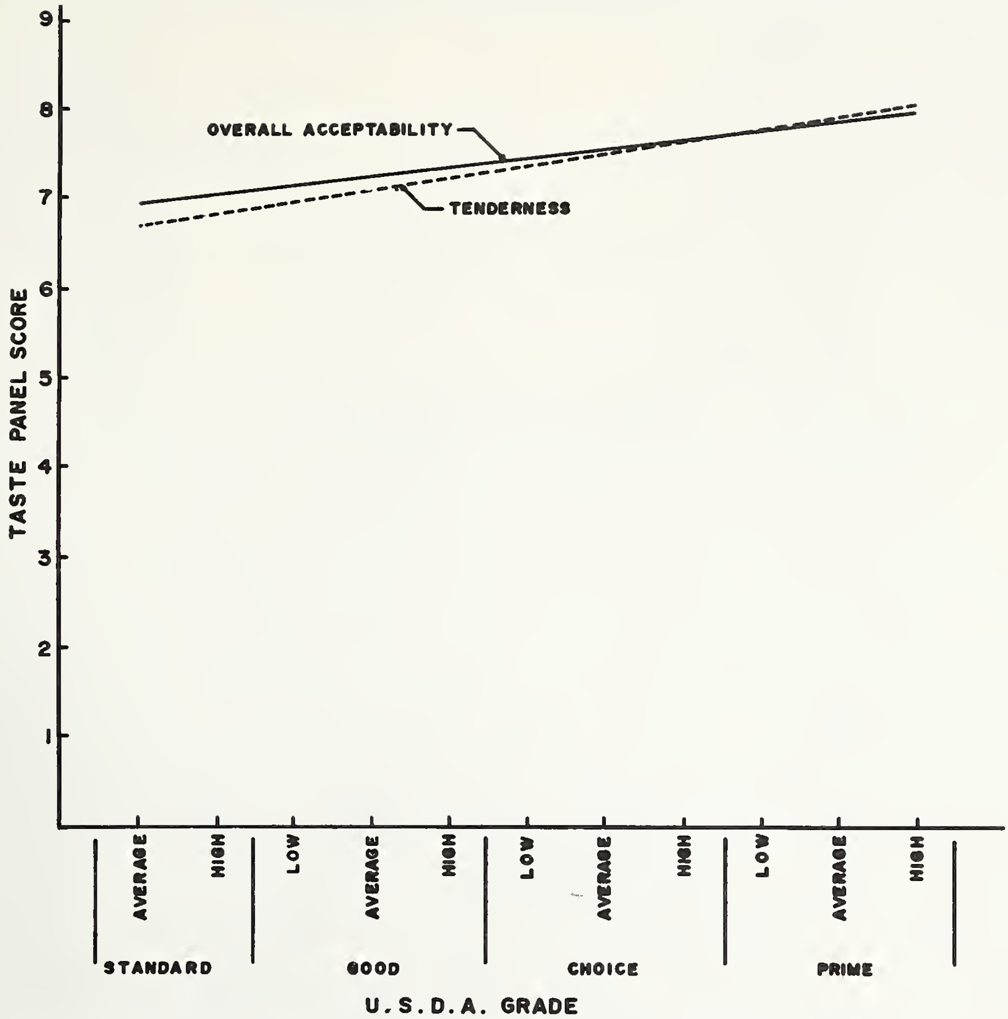

Figure 15.—Graphic illustration of changes in taste panel overall acceptability and tenderness with changes in final quality grade.

Because an official USDA yield grading system is now available, conformation does not appear to be a useful factor in the quality grade standards.

Conclusions

1. Marbling was the only palatability indicator significantly related to all of the taste panel traits.
2. The components of final quality grade (conformation, maturity, marbling, and color, firmness, and texture of lean) accounted for no more than 10 percent of the total variation in palatability traits.
3. Palatability of rib steaks from steers, 15 to 18 months old and differing greatly in growth characteristics and body composition at time of slaughter was acceptable when the ribeye contained as little as 2.9 percent chemical fat (the equivalent of Good minus).
4. Increased time on feed was associated with increased external and intramuscular fatness but did not result in a net change in taste panel evaluations.
5. Conformation served no useful purpose in the quality evaluation of young steer carcasses.

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